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"DID it ever occur to you, Ed, what a mass of information and instruction there is bound up in a copy of POWER?"

"Now that you mention it, no. But I do know that it is a big nickel's worth of reading for anyone in our line."

"As an experiment, I sat down the other night to read my paper in a scientific way. We have been hearing a lot about scientific this and scientific that, and I decided I'd try a little science in my way of reading. I picked up a copy of the latest issue (October 3) and as I idly glanced at the cover, wondering just what would be the most scientific way to start my reading, my eye fell on the words, 'Outline of Topics on page 74,' printed on the cover. I had never noticed it before and, thinks I: 'Your Uncle Bill is not so well acquainted with his paper as he thought he was. I must look to see how long this thing has been going on.' Looking through the back numbers, I found September 19 was the first issue.

"I turned to the 'Topics' page in the issue I was going to read and found a table of all the titles in the magazine and a neat note of explanation for each big article.

"'This is all right,' thinks I; 'here is the place to begin to get scientific.' I skimmed over the titles and checked off four articles to read first, as these seemed to be most worth my time. Of course, I always read the 'Readers with Something to Say' department, 'Questions before the House' and the 'Inquiries of General Interest' page. These three are bread and butter to me, being, as I am, a man on the job.

"My idea of scientific reading is to read first everything that is important to me. Then, if I have any time left over, I read the stuff not quite so vital.

"I get a lot of fun out of reading the 'Inquiries' page like this: I cover the answer with a slip of paper, read the question and then try to answer it myself. Then, I compare my answer with the printed answer. Sometimes my guess is a thousand miles off the right track.

"In the part for readers with something to say, the idea about an engine-room log book is a mighty fine one, although it isn't very new. If more engineers would keep such books it would be better for them. The letter about running a Corliss with only one steam valve is very interesting. The cause of Mr. Hyde's trouble with corrosion seems to be baffling, as does Mr. James' case of erosion. There seems to be very little generally known about these two forms of destruction. Mr. Dickson is rather rough on the fellows he calls scrub engineers, although I guess there is lots of ground for his complaint.

"The most important general article I checked off was 'Centrifugal Pump Capacity and Speed.' When I first looked at this article it seemed rather formidable on account of all the fancy-looking formulas it has. But, after I bit into it, so to speak, I found nothing to stump me at all. The article is along good practical lines and just what men like you and me need occasionally. I know more now about centrifugal pumps than I ever did and if I happen to need a new pump some time, I'll have some sane ideas to work with and I'll be able to put my hand on the rule for finding the capacity or speed in no time, for I filed that article with my other engineering literature.

"What I liked particularly about the article was the fact that in the mathematical work the rule was stated first, then the formula was given and finally an actual example in figures was worked out. Now, any man who understands arithmetic at all ought to be able to use those formulas after that.

"As it is getting a bit late now I won't make your ear sore by talking to you any more. I'll simply say that after getting through with the more important articles I started to read the others and found that, although they were sometimes a bit out of my line, and in spots over my head, they were interesting, in spite of this, and served to increase my general store of knowledge."

A Light, Heat, Power and Ice Plant*

By J. O. Olson

A small central station containing Corliss engine-driven generators and ice machines. Light, heat, power, ice and water are supplied to Clarinda, a typical Western town in Iowa. Because of the variety of service furnished, the load factor is exceptionally high.

*Submitted to the Institute of Operating Engineers as thesis to qualify for degree of Master Operating Engineer.

The Lee Electric Light Company, in Clarinda, Ia., operates a small combined light, heat, power, refrigerating and water-pumping plant which is interesting in many respects. Clarinda is a going little town of 4000 inhabitants, typical of the West.

By virtue of the variety of service which the plant performs, its load factor is exceptionally high. In the summer time, when the ice business is good, the lighting load is less than in the other seasons when little artificial ice is needed. The water-supply system includes a standpipe which is filled by the pumps of the plant; thus the pumps may be run at almost any period of the day which is best suited to conditions.

During the heating season practically all of the exhaust steam is sent uptown and sold to the company's numerous customers.

The present equipment of the plant consists of the following:

Buildings

The power-plant building is of brick 60x100 feet, of which 40x60 feet is boiler room and the remainder, 60x60 feet, is engine room, of which 20x40 feet is reserved for future equipment but is at present occupied by the company's office. The basement of this building contains the feed pumps, exhaust-steam separators and the return tanks of the steam-heating system, also a quantity of steam, water, air, oil and ammonia piping, electric conduits, etc.

The ice-making and cold-storage building is of concrete construction for the first story with hard red brick and hollow building tile for the two upper stories. This building is 52x140 feet. There are 30 feet of vacant ground between the two buildings, but the two are connected by a concrete tunnel in which are racks for all the piping and conduits leading from one building to the other. There is also an inclosed passageway above ground. About two-thirds of the building are taken up by cold-storage rooms; the walls, ceilings and floors of all rooms are insulated part with two layers of 2-inch nonpareil cork and part with two layers of 2-inch xylolith; the sharp freezer has two layers of 3-inch nonpareil cork; all insulation is plastered with portland cement. Direct expansion in 2-inch pipe coils is used throughout. The temperatures held are from five degrees below zero up according to the goods stored. The remaining one-third of the building is occupied by a 240-can ice-freezing tank using 300-pound cans, an electric store room and shop, pipe shop and fitting racks, and a barn for four ice-delivery teams, etc.

Boilers

There are four 60x16-foot return-tubular boilers equipped with Jones underfeed stokers.

All four boilers are set side by side in one battery. A 36-inch smokebox or breeching extends across all four uptakes and connects with two 36-inch by 100-foot steel stacks, one at each end of the breeching. Dampers in the smokebox are so arranged that either stack can be cut out or both may be used at once, or one for each two boilers. The pressure carried is 115 pounds (gage) and seldom varies as much as 5 pounds. The fuel used is mostly slack, very low in heat value. No trouble is experienced in burning it, however, and the stacks are for the greater part of the time almost smokeless.

Fig. 1. Cold-storage Building in Foreground and Engine House to the Right

Engines

There are four Murray Corliss engines, two for the electric generators and two for the ammonia compressors. These are all of the simple noncondensing type. One is 16x30 inches in size and of the heavy rolling-mill design, direct connected to a 150-kilowatt, two-phase, 60-cycle, 2200-volt revolving-field, National Electric Company generator running at 120 revolutions per minute. One is 16x36 inches in size and of the same type but belted by rope drive to a 100-kilowatt, two-phase, 60-cycle, 200-volt, revolving-field Warren Electric Company induction-type generator, running at 600 revolutions per minute while the engine speed is 80 revolutions per minute.

The other two engines are 12x30 inches, and 12x24 inches in size and of the girder-frame type. These engines are each direct connected to a 10¾x17-inch Wolf-Linde ammonia compressor rated at 30 tons each when running at 77 revolutions per minute.

A small high-speed engine 5x6 inches in size and of the American Blower Company's make, drives the fan and the stoker mechanism. The speed of this engine is governed by the steam pressure. The governor consists of a diaphragm valve so connected that it will close as the pressure increases and open as the pressure decreases; thus the speed of the engine and stoker equipment increases inversely as the steam pressure. This arrangement is quite sensitive and and results in a very steady steam pressure.

Pumps

The feed pumps are three in number, one 8 and 5 by 12-inch outside center packed Burnham pump; one 5¼ and 3 by 6-inch duplex Canton pump; one 5½ and 3½ by 6-inch March pump. There is also a small March pump for the oiling system.

The water supply for the plant is furnished by two Cooks deep-well steam pumps. The steam cylinders of these pumps are 10x36 inches, having 6-inch working barrels about 60 feet below the pump heads.

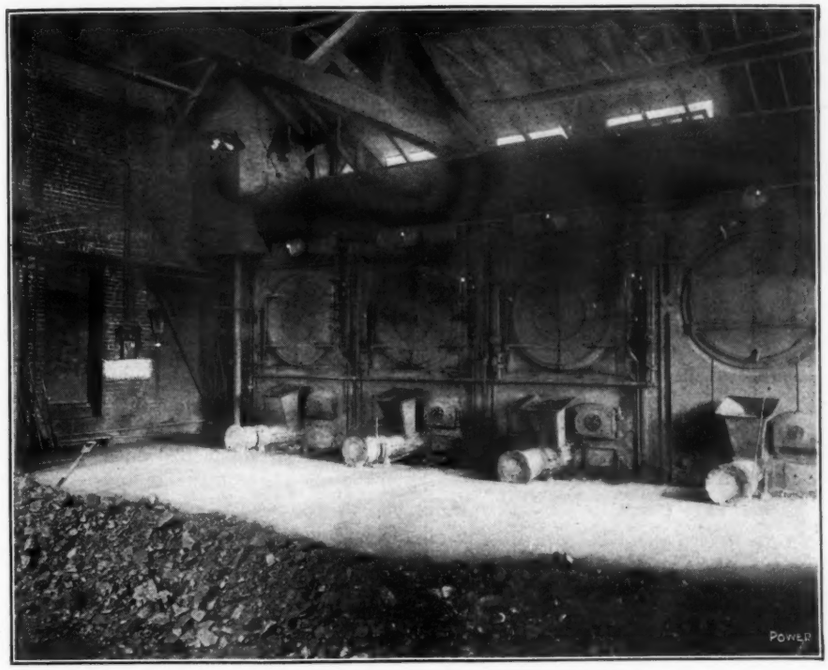


FIG. 2. THE BOILER EQUIPMENT

There are also three motor-driven Goulds deep-well pumps located about a mile from the plant. These are used for city water pumping only. These pumps have 24-inch strokes and 6-inch working barrels down about 50 feet below the working heads. There is also one pump of the same type which is doing railroad pumping. The city water system is of the standpipe type and the railroad has a large supply tank, consequently we are enabled to do most of the pumping during the hours when the other load is the lightest.

The water for the plant itself is used to advantage step by step. It leaves the wells at a temperature of about 54 degrees and is sent through the double-pipe ammonia condensers. This, of course, raises its temperature some 10 to 15 degrees. What water the plant does not need itself is sold to the city; the remainder is run over the steam condensers which make the distilled water for ice manufacturing. The condensing water now is about 150 degrees and goes to the Baragwanath open feed-water heater from which it leaves at a temperature close to 212 degrees, besides having got rid of many of its impurities and much scale-forming matter.

STEAM HEATING

The steam heating amounts to about 35,000 square feet of radiation. Two 6-inch mains and two 2½-inch returns leave the power station and form a complete circuit around the business square. One 5-inch main is run in the opposite direction into the residential district, supplying both sides of the street for four blocks. This main has no return pipe, the steam traps discharging through condensation meters to the sewers, the charge for heat being based on the number of pounds of steam condensed. The heating supplied in the business district is charged for mostly on a basis of the number of square feet of radiation served. In this case the customer's steam traps discharge into the return main and the water returns by gravity to the receivers and feed pumps in the station basement. This water has a temperature of about 165 degrees and as it is perfectly free from any scale-forming matter it makes a good boiler feed. Part of it is used for filling ice cans as considerable ice is made during the heating season. This makes it possible to send the exhaust from the ice machines also uptown for heating. It also results in quite a saving in well water as the atmospheric condensers for the making of distilled water are cut out altogether. Finally, it saves boiler-feed water and boiler compound.

The pressure carried in the heating is from atmospheric up to 3½ pounds, according to the weather and the demand for steam. All engines and auxiliaries have their exhaust piping so arranged that any one, or as many as necessary, can exhaust either to the heating system or to the atmosphere through the exhaust feed-water heater or to the atmospheric condenser for distilling water; thus no engine need work unnecessarily against back pressure. In case the exhaust is not sufficient to keep up a predetermined pressure, live steam is automatically supplied through a very sensitive regulator. A back-pressure valve is provided which acts as a safety valve against overpressure.

The heating mains and returns are all insulated with Wyckoff wood lagging. All pipe lines are carefully graded and given as much pitch or fall as possible so as to drain perfectly at all times and under any pressure. This point the writer has always considered as being very important in order to prevent waterhammer, to reduce back pressure on the engines and to get the full capacity of the pipe lines with as low a pressure as possible. Expansion is another factor in connection with the heating and return mains as well as with the branches that calls for close

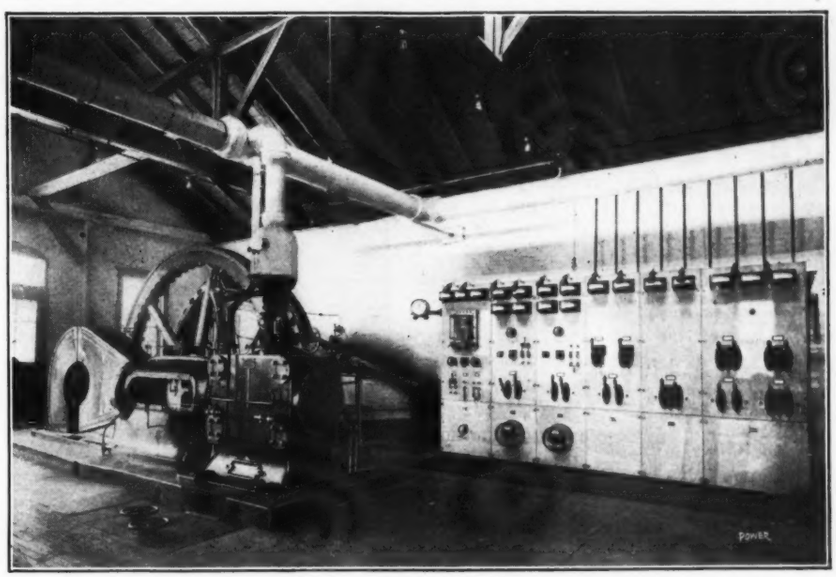


FIG. 3. THE DIRECT-CONNECTED UNIT AND THE SWITCHBOARD

attention. Wherever possible, the expansion is taken care of by long sweep bends. But on long straight lines slip joints are installed and in a few cases swing joints are used. The greater part of the system has been in operation seven years, and has, as yet, not had a leak, break or rupture in any underground pipe.

Switchboard

The switchboard consists of six marble panels as follows: One exciter and regulator panel, two generator panels and one panel for incandescent lighting, one for power and one for arc lighting. This board has all of the latest equipment, such as integrating and indicating wattmeters on the generator panels, besides the regular voltmeters, ammeters, etc. The exciter panel carries the Tirrill regulator, the synchroscope, ammeters, voltmeters, switches, rheostat wheels, etc., for the two exciters.

The back of the board has two sets of busbars arranged for either running parallel or independent; all high-tension current is handled through oil switches, all circuits are equipped with automatic circuit-breakers, all wires come and leave the board in iron conduits, and no high-tension current appears on the front side of the board.

Electric power is supplied to practically every power user in Clarinda. An eight-mile line to supply light and power to another town (New Market) is now under construction, and the prospects are that several other small towns and villages in the neighborhood will be supplied in the near future. This plant was not all built in a day, but has had a steady growth from the start. The writer is at present making plans for a new generating unit and an additional switchboard, a submerged coal-storage and coal-handling equipment, additional cold-storage rooms, and auxiliary equipment incidental to these installations.

Boiler Efficiency of 83.69 Per Cent.

Description of two tests made of a Parker boiler at the Fruitvale station of the Southern Pacific Company which indicated efficiencies of 83.69 and 83.17 per cent. Oil was used as fuel.

The Southern Pacific Railroad recently put its Fruitvale, Cal., power station into service. This station furnishes current to the company's electrified suburban lines which run between Oakland and the numerous suburbs of that city and San Francisco. The plant is laid out according to the latest approved practice, and high economy might naturally be expected of it.

The possibilities of the station for developing current economically are suggested in the following abstract of the report of two boiler tests which were recently conducted under the direction and supervision of R. F. Chevalier, consulting engineer and specialist in steam power-plant economy.

The object of the tests was to determine the efficiency of the boiler under normal load. The first test was made in compliance with a guarantee clause in the contract between the manufacturer and the purchaser, and as the indicated efficiency was so high it seemed advisable to check it by conducting another test. The second test was conducted in the presence of Prof. W. F. Durand, of Leland Stanford University, and W. C. Miller, engineer of power stations for the Southern Pacific company.

The boiler tested is a Parker water-tube, rated by the builders at 645 horsepower and designated as a compound three-pass type. It contains 280 four-inch tubes, 17 of which are 20 feet, 6 inches long, 17 are 22 feet, 6 inches long and the balance 20 feet; two steam and water drums, 54 inches in diameter and 22 feet long, and one superheated steam drum 18 inches in diameter and 20 feet long.

The superheater originally consisted of 40 loops of 1¼-inch tubes and contained 134.4 square feet of surface; later, this was cut down to 107.5 square feet by the removal of eight loops.

The steam and water drums are divided by a horizontal steel diaphragm riveted to the shell and extending from the rear head to within a short distance of the front head. To the front end of this diaphragm and to the lower part of the drum is riveted a vertical steel plate forming a pocket at the front to collect the scale discharged from the tubes and dividing the drum into two separate chambers. In this plate is a manhole having a hinged cover on the inside which when closed makes a water-tight joint. The pivot on which this cover swings is at the top of the manhole and the weight of the door keeps it closed under normal conditions. This swinging manhole plate acts as a nonreturn or antipriming valve. Its function is to allow the water discharged into the upper compartment to enter the lower compartment of the drum but to prevent the return of any water to the former. The upper section in the drum is known as the steam space, the lower as the water space. The bottom of the drum below the level of the nipples leading to the tubes forms the sediment pan or mud drum. An inverted angle iron with closed ends is placed over the

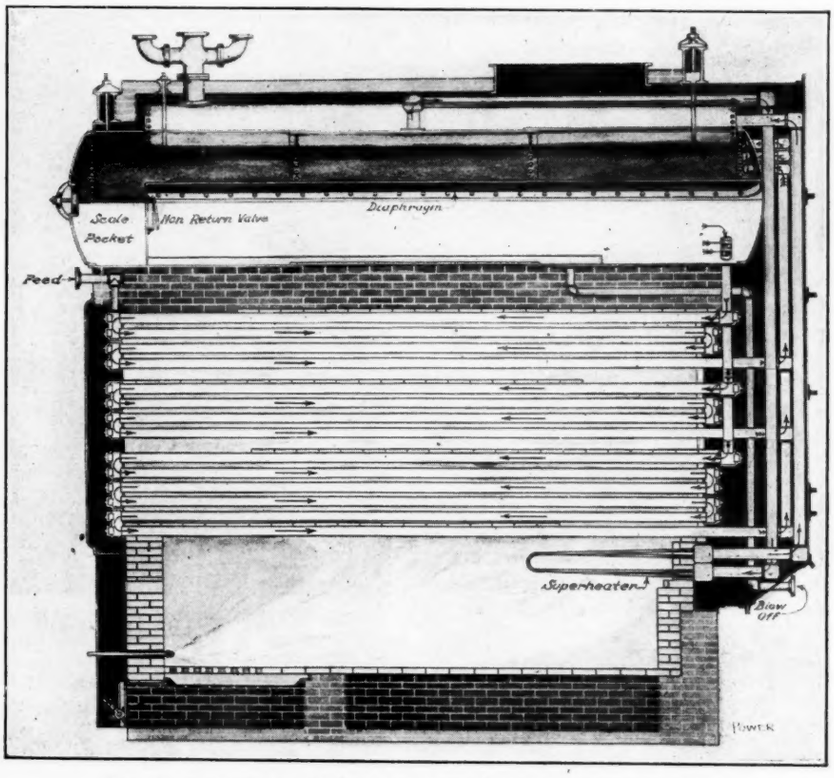


Fig. 1. Sectional View, Showing Design of Boiler Tested

blowoff opening, thus making the blowoff effective over a considerable area.

The tubes are divided into three banks, each bank forming a pass. The upper bank is known as the feed element and

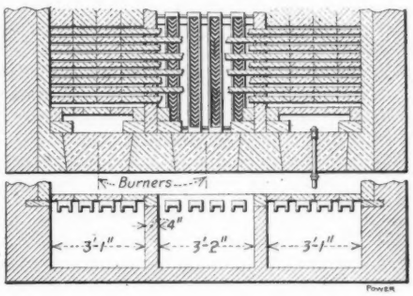


FIG. 2. PLAN AND SECTION OF FURNACE

acts as an economizer through which the feed water must pass before entering the drums. The intermediate and lower banks are termed steaming elements. The bank of tubes comprising the economizer is 20 tubes wide by 4 tubes high, and is in the third pass of the gases. This bank is divided into two parts, each 10 tubes wide by 4 tubes high, each of these parts discharging into the drum above. The feed water enters the front end of the first tube in each of these parts, which are the upper wing tubes. At the rear of each of these tubes a connection is made between the junction box and the respective drums with an expanded nipple. In the junction box is placed a nonreturn valve which prevents the feed from going the wrong way and entering the drum through the inlet connection. The flow in the economizer elements is forward and backward alternately through the tubes in the top row, then down to the next row, and so on, finally discharging through two vertical upcasts into the rear head of the drum above the diaphragm. The water then flows along the diaphragm into the front pocket, through the swinging manhole and into the lower or water chamber of the drum, whence it flows by gravity to the steaming elements. If the feed is shut off, the drum connection furnishes the economizer elements with water.

The intermediate bank of tubes is in the second pass of the gases and is composed of five elements, four tubes wide and four tubes high. The water from the drum enters these elements on the upper or induction end through a downcast tube which is expanded in an inlet box supplying two elements. Each element has a nonreturn valve in the inlet box which prevents the reversal of the flow of water. The water in these elements passes four times across, thence down to the next row, and so on through the remaining tubes to the lower end of each element which is connected to the steam chamber by an independent upcast discharging into the steam space of the drum.

The lower bank of tubes consists of 10 elements, two tubes wide and six high. The tubes in these elements, with the exception of the lower row which are in the furnace, form the first pass. The upper ends of the elements are connected to the drums by means of downcast tubes and inlet boxes in the same manner as before mentioned. The water

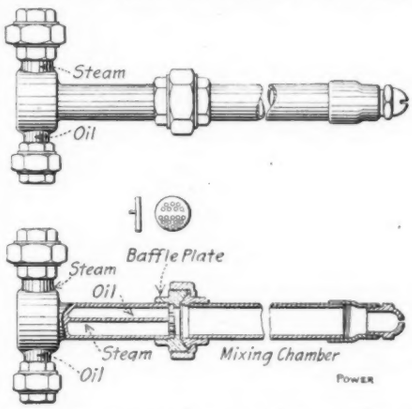


FIG. 3. DESIGN OF FUEL-OIL BURNER USED

entering these elements passes across two tubes, thence down and across two tubes, and so on to the last tube, whence it is discharged into the drum through an independent vertical upcast.

FURNACE

The furnace is of the ordinary type, having grate bars such as are used for burning coal; the bridgewall has been left out. The furnace is 10 feet wide by 16 feet 8 inches long, with an average hight of 4 feet between the tubes and the furnace floor, making a volume of 666 cubic feet. Three burners, equally spaced across the width and with the tips extending 2 inches into the furnace, enter through the boiler front. In front of each burner a rectangular area on the

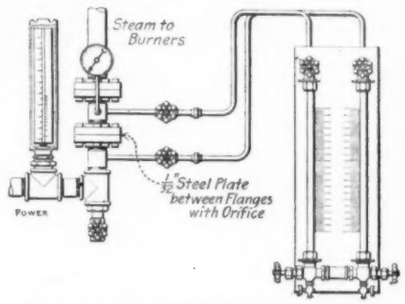


FIG. 4. ARRANGEMENT FOR MEASURING STEAM TO BURNERS

grate bars, 37 inches wide by 42 inches long, was left uncovered. On this area were placed soap firebrick, laid in loosely and arranged so as to allow the admission of air for combustion through small openings running crosswise to the direction of the flame. A large rectangular opening was left beneath each burner. The ashpit is subdivided into three compartments, each of which supplies air to the individual setting for each of the burners. For arrangement and details see Fig. 2.

An internal mixing type of burner, manufactured by P. J. Owens and illustrated in Fig. 3, was used.

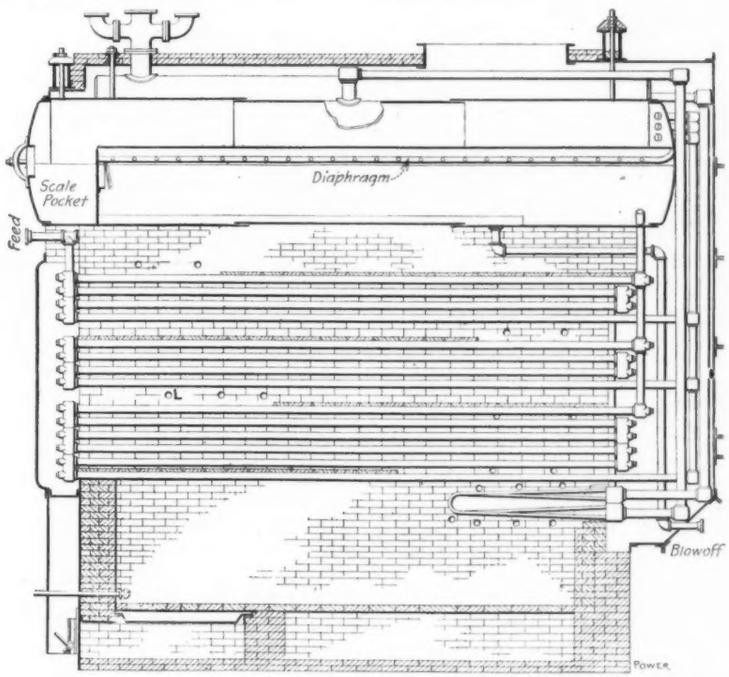


FIG. 5. LOCATION OF HOLES IN FURNACE WALL FOR PYROMETERS AND FLUE-GAS SAMPLING TUBE

The apparatus for weighing the feed water consisted of two pairs of platform scales placed upon a staging. On these scales were placed the tanks in which the water was weighed. After being

weighed the water was emptied into a receiving tank beneath, from which it was delivered to the boiler by a special pump. A hook gage was placed in the receiving tank and at the beginning of the test the tank was filled so that the point of the hook just broke the surface of the water and at the end of each hour the water lever was brought to this point. The water in the boiler was maintained at as near a fixed level as possible. The outlets from the blowoffs were disconnected and blanked. The outlets from the water column and gage glasses were carefully watched; no leakage occurred from either. At the end of each hour the actual amount of water used was checked. The scales were standardized by representatives of the manufacturer.

The apparatus for handling and weighing the fuel oil consisted of a standardized platform scale placed upon the same staging that carried the scales for weighing the water, and upon this scale a tank into which the oil was pumped as required. From this tank the oil, after being weighed, was run by gravity into a receiving tank beneath, from which it was taken by a pump, passed through a heater and thence to the burners. The oil pump was fitted with a governor and an automatic relief valve. Thus, a constant pressure was maintained in the oil line to the burners. The discharge from the relief valve led back to the tank from which the supply to the pump was taken. As the oil was emptied from the weighing tank a small sample was collected four times each hour. The samples thus collected represented a fair average of the quality of oil used.

At the completion of the test of January 5, the samples of oil were thoroughly mixed and divided into four portions, and placed in small tin containers and sealed. One sample was delivered to the Southern Pacific company, whose chemist made an analysis; one was used in Mr. Chevalier's laboratory for analysis and the other two were placed in storage for future reference if necessary. The results of the analysis by the Southern Pacific company's chemist showed a lower heat value than that determined by Mr. Chevalier. For the test of March 18, a sample was sent to Prof. Edmund O'Neil, dean of the department of chemistry of the University of California, Berkeley, for determining the heat value and water contained in the oil. As the results obtained by Mr. Chevalier were confirmed by those of Professor O'Neil they only are given in detail in the present report. A Parr calorimeter was used by Mr. Chevalier in determining the heat value. Two determinations were made on each sample and the results averaged. The water contained in the oil was determined by distillation, and the specific gravity was determined with a Westphal balance.

Steam Used by Burners

The steam supplied to the burner was measured during the test of March 18. The method of measuring this steam is as follows: A diaphragm with an orifice 0.5 inch in area was placed in the steam-supply line. On either side of the diaphragm holes were drilled and tapped for two ¼-inch pipes, these pipes being connected to the legs of a manometer filled with mercury. In the steam pipe, ahead of the diaphragm, was placed a pressure gage and beyond the diaphragm a thermometer was inserted to determine the temperature of the steam. The arrangement of this apparatus is shown in Fig. 4. After the test the orifice was calibrated by passing steam through under a series of observed conditions, the amount of such steam being determined by condensation and weighing. The amount of steam used by the burners was found to be 4.16 per cent. of the total water evaporated.

All of the thermometers, gages and scales used in the tests were calibrated and proper corrections were made in the final computations.

RESULTS OF EVAPORATIVE TESTS ON A 645-HORSEPOWER PARKER BOILER AT FRUITVALE POWER STATION

	Jan. 5, 1911	March 18, 1911
Date of test		
Duration of test, hours	8	10
Type of burner	internal mixer	
Make of burner	Owens	
Number of burners used	3	3
Water-heating surface, square feet	6,457	6,457
Superheating surface, square feet	134.4	107.5
Average Pressures:		
Barometer, inches of mercury	30.4	30.1
Steam pressure by gage (saturated), lbs. per square inch	178.5	179.7
Oil pressure at burner, pounds per square inch	78	92
Force of draft in flue after damper, inches water	0.31	0.294
Force of draft between damper and boiler, inches water	0.165	0.15
Force of draft in furnace near superheater, inches water	+0.01	+0.016
Force of draft in ashpit, inches water	0.02	0.02
Average Temperatures, Degrees Fahrenheit:		
External air		
Fire room	75	78
Air entering ashpit	75	81
Furnace (6 feet from burner tip)	2,275	2,390
Gases entering first pass	1,680	
Gases leaving first pass and entering second	885	915
Gases leaving second pass and entering third	610	690
Gases leaving third pass and entering fourth	400	420
Gases escaping from boiler	384	394
Oil at burner	128	113
Feed water entering boiler	165	123.4
Superheated steam	539	561.2
Saturated steam due to pressure	379	379.5
Degrees of superheat	160	181.7
Fuel:		
Kind	crude oil	crude oil
Gravity of oil at 60 degrees F., specific	0.9700	0.9627
Gravity of oil at 60 degrees Fahrenheit, degrees Beaume	14.43	15.37
Percentage of water in the oil	1.2	0.6
Calorific value of dry oil per pound, B.t.u.	18,513	18,681
Weight of oil as fired, lbs	11,841	14,093
Weight of oil consumed corrected for moisture, lbs	11,699	14,008
Volume of moisture-free oil consumed, bbls	34.5	41.56
Fuel, Average per Hour:		
Oil consumed per hour as fired, pounds	1,480	1,409
Oil consumed per hour corrected for moisture, pounds	1,462	1,401
Volume of dry oil consumed per hour, barrels	4.31	4.15
Oil per hour corrected for moisture per cubic foot of furnace volume, pounds	2.195	2.1
Oil per hour corrected for moisture per square foot of heating surface, pounds	0.226	0.217
Water:		
Total weight fed to boiler, pounds	156,974	180,240
Factor of evaporation	1.19	1.244
Equivalent evaporation from and at 212 degrees, pounds	186,799	224,218
Water, Average per Hour:		
Water evaporated per hour	19,621	18,024
Equivalent evaporation from and at 212 degrees, pounds	23,350	22,422
Equivalent evaporation from and at 212 degrees per square foot of water heating surface, pounds	3.62	3.47
Horsepower developed, A.S.M.E. rating	676.7	650
Builders' rated horsepower	645	645
Percentage of builders' rating developed	105	100.8
Economic Results:		
Water evaporated under actual conditions per pound of oil as fired, pounds	13.256	12.79
Equivalent evaporation from and at 212 degrees per pound of oil as fired, pounds	15.775	15.91
Equivalent evaporation from and at 212 degrees per pound of oil corrected for moisture, pounds	15.967	16.01
Efficiency:		
Efficieney of the boiler, per cent	83.69	83.17
Analysis of the Dry Gases by Volume:		
Carbon dioxide (CO_2), per cent	13.05	13.5
Percentage of excess air above amount theoretically required	18	14

To determine the amount of air entering the furnace, an analysis of the gases of combustion for carbon dioxide was made by the use of the standard form of Orsat apparatus. Samples were taken where the gases leave the first pass and enter the second. The sampling tube was inserted at *L*, Fig. 5.

The following observations were taken every 15 minutes: Steam, oil and draft

pressures; temperature of the superheated steam, steam to burners, feed water, fuel oil, boiler room, air entering ashpit and escaping gases. The temperature of the furnace and that of the gases passing through the boiler were taken every 10 minutes. For determining the furnace temperature, a Fery radiation pyrometer was used. The temperature of the gases through the boiler was taken with a Bristol electric pyrometer, several couples being used and placed at points where the gases left one pass to enter another. The positions of these couples are shown in Fig. 5.

The fires for the first test, January 5, were lit on the evening of the fourth and the boiler was maintained in a standby condition throughout the night. At 8 a.m., January 5, steam was drawn from the boiler so that the fires might be burned at normal intensity. The test was started at 9 a.m. and continued until 5 p.m. During the test, the fires were tended by a regular fireman, who adjusted them according to instructions. The draft regulation was attended to by Mr. Chevalier. The boiler had been in operation since November 30, 1910. Prior to the test, the water had been drained from the boiler and the internal surfaces inspected. In the lower and intermediate steaming elements there was no deposit of scale, but in the feedwater element a slight scale was found, the thickness of which was about 1/32 inch. Both drums had a soft, slushy mud covering the bottom about 6 inches deep for its full length. This mud was removed and the drums washed. None of the tubes was cleaned internally. The soot was thoroughly blown from the heating surface on January 4.

Test of March 18, 1911

In the interval between January 5 and March 18, the boiler had been operated intermittently at about one-half of its rating. Prior to the test, the boiler was opened and the tubes in the feed-water element were scraped; the tubes in the intermediate and lower elements required no cleaning.

Fires were started under the boiler on the evening of March 16 and moderate fires were maintained through the night. A test was made on March 17, but owing to the irregularity of the load on the boiler it was deemed advisable to make another test on the following day. Light fires were again kept under the boiler during the night. At 9 a.m., on March 18, steam was drawn from the boiler so that the fires could be burned at normal intensity. The test was started at 10 a.m. and continued until 8 p.m. At 1:33 p.m. a strainer in the steam line to the oil pump filled with scale from the steam pipe, necessitating a shutdown of three minutes until the strainer could be taken out. The fires had to be extinguished, but the flow of steam from the boiler was not interrupted, thus causing a drop in the pressure. The soot had been blown from the tubes on March 16, and thus the boiler had been operated for about 30 hours before the time of the test without further removal of soot.

Although the heating surface of the superheater had been decreased, the degree of superheat was more in this test than in that of January 5. This was due to the fact that the opening through the baffles between the furnace and the first pass had been shortened, causing a greater volume of the gases to sweep over the heating surface of the superheater. In all the tests conducted, no blisters or signs of distress appeared on any of the tubes.

Engine and Machinery Foundations

By A. E. Dixon

Bed rock makes the best natural foundation. Dry sand or gravel comes next. Quicksand, when in thick beds, requires piling. Piles should be cut off below the water line and capped with concrete. Direct-connected machinery does not need as massive foundations as other types.

The first and most important purpose for which foundations are employed is to insure that any settlement which occurs will be uniform; the second is to provide an anchorage. This last purpose may be accomplished in combination with the first, but an anchorage is only necessary where the energy developed in the machine is not absorbed or utilized in a direct-driven machine, as in the case where the power is taken off by or delivered to the machine by belts or ropes. Anchorage is also required by reciprocating machines which are improperly balanced or in which the direction of motion is reversed abruptly, the mass of the foundation serving to absorb and dampen vibration. There are some classes of machines which can be safely set without either foundations or holding-down bolts, as rotary converters and turbo-generators or similar combinations mounted upon rigid bedplates. The only requirement in these cases is that the supporting structure shall have sufficient rigidity and be capable of meeting the concentrated loadings imposed.

Rock bottom is most desirable where piers supporting heavy machinery are to be put in, but it may introduce complications in getting rid of vibration. Rock has a tendency to transmit shocks or vibrations to all surrounding structures resting upon the same bed, and where there is any chance of vibration a bed of dry sand from 6 to 12 inches thick must be placed between the rock and the foundation. This sand bed can be made within a pocket excavated in the rock or, where a flat bed exists without natural retaining walls, by building a pocket of concrete to hold the sand in place. Mineral wool and felt cushions have been utilized under light foundations, but they do not possess the lasting qualities of sand.

There are many different grades of rock and the natural bed of the stone may be at any angle between the horizontal and the vertical. The most favorable conditions are those in which the rock has a horizontal bed and does not disintegrate upon exposure to atmospheric influences. Some rock is called "rotten" because it deteriorates and softens upon exposure, while in other cases beds of rock are found which upon their first exposure are soft enough to excavate with a pick and shovel but harden rapidly and must be blasted after exposure. Many other outcrops require blasting, while in still other cases the natural cleavage permits its removal with wedges; in some of the softer rocks this method of breaking up into derrick or one-man or two-man sizes is less expensive than block-holing and using powder.

The safe loading upon rock depends entirely upon its nature, and ranges from 5 to 200 tons per square foot. In cities having building codes the safe-load limitations of the natural soils found within their limits are specified. Where there is no building code the safe loadings can be governed by the values given in Baker's "Masonry Construction." This table has been widely copied and may be found in many handbooks.

Sand or gravel, particularly when dry and well drained, is next to rock in desirability, and in some respects is the best substratum. It is easy to excavate, and if free from clay and loam the excavated material can be utilized in making mortar or concrete, thus reducing the expense of masonry construction. Other soils have to be removed and used for

grading low places or back filling, and the disposal of the surplus soil may considerably increase the expense of excavating.

Mud, soft alluvial soil, quicksand, etc., often make foundation work difficult, particularly where heavy concentrated loads are to be carried. Piling or raft foundations then become necessary. Where the water level is permanent, wooden piles cut off below this level will endure as long as the structure above them.

There are two methods of capping a wood-pile foundation. One is to excavate between the piles for a depth of 2 feet or a trifle more; then fill in around the piles to a depth of a foot with clean sand and upon this a bed of concrete is laid. The depth of this concrete over the heads of the piles will depend upon conditions and the load. An interesting example of concrete mat over piles is found in the foundations of the Long Island City power plant of the Pennsylvania Railroad. This mat is 6 feet 6 inches thick at all points except under the four stacks, where it is 2 feet thicker. The site of this foundation is inclosed within sheet piling. In this case the thickness of the mat was partly dictated by the tidal conditions of the East river, on which the plant is located. The floor of the power-house basement had to be above high water while the piles had to be cut off below low water. Sheet piling is necessary in building foundations of this kind in order to prevent the earth about the excavation from caving in, and to prevent damage to adjacent structures. It also serves to limit the quantity of water flowing into the excavation and reduces the expense of keeping the pit dry. Where the surrounding soil is subaqueous, cofferdams constructed of sheet piling or cribwork are required.

The earliest method of capping a pile foundation consisted of laying heavy squared timbers on top of the piles to which they were secured by drift bolts. On top of these and at right angles to them another layer of squared timbers was laid. These two layers were usually of 12x12-inch material. The interstices between the timbers were then filled with sand, gravel or concrete and a flooring of 6x6-inch timbers was laid over the area. These timbers were solidly drift-bolted together and upon the surface thus prepared was laid the stone or concrete masonry for the foundation. This method was very expensive as the piles had to be cut off low enough to keep all of the timber work below the water line.

There are a number of formulas for determining the bearing power of piles. Most of these depend upon the distance the pile sinks under the last few blows of the pile-driver drop. These are very poor ways of determining how much the pile will sustain, though they are widely used by engineers who should know better. The writer has seen a pile sink 3 feet and more under one blow of the hammer and then come up nearly the same distance as soon as the hammer was lifted off its head. Holding this pile down with a heavy weight for a short time resulted in its becoming so firmly fixed in position that repeated blows with the hammer could not drive the pile down ¼ inch; when the endeavor was made to pull the pile the heaviest tackle available could not stir it. The use of formulas based upon the distance the pile sinks under one blow has often resulted in driving the piles down into themselves until they split and lost strength.

Quicksand, when it reaches a considerable depth, can be overcome by driving piles down to the firm underlying stratum. Thin layers can be removed by placing sheet piling around the area to be excavated; inflow will also be prevented by this means, as this is the main trouble in such cases.

Medium beds occasionally present themselves. The writer once put in a heavy foundation for a twin reversing engine with 55x60-inch cylinders driving a 34-inch blooming mill, the entire area of which was underlaid by a bed of quicksand about 12 feet thick. The method adopted in this instance was to drive two rows of sheet piling about 3 feet apart, inclosing the area for the foundation. The space between the sheet piles was then excavated, the piles being held in position by heavy bracing. This excavation was carried down 2 feet into the firm layer of hard pan underlying the quicksand and then filled with concrete, this forming a concrete cofferdam around the foundation area. The space inclosed was then excavated to the required depth, which left 10 feet of quicksand below the foundation. This sand was so fluid that a man could not stand in it unless supported by a plank. The surface of the quicksand was then covered with two layers of tar paper at right angles to each other and a thin layer of concrete was deposited on the tar paper; then a 2-foot layer of concrete was deposited to form the foundation footing. This method of doing the work saved nearly 1000 cubic yards of concrete, and the foundation proved all that could be desired. No appreciable settlement had occurred when the elevations were checked up by a bench mark after the machinery had been operated several years.

The holding-down bolts in these foundations were from 1 to 3 inches in diameter and from 4 feet 5 inches to 16 feet in length, 241 bolts being required for the engine, mill, tables and shear. Templets, made from drawings, were made in sections to locate these bolts and all holes were laid out by measurements from center lines, a hole being bored in the templet for every bolt. The templets locating the heavy bolts were so supported on a scaffold that their lower surfaces were slightly above the elevation of the top of the foundation. A transit was used to line up the templet and after it had been accurately located it was nailed fast to the supporting scaffold. In the meantime the bolt pockets in the lower part of the foundation were brought up to the level for the foundation washers. These washers were set in position and located by plumbing down from the templet.

Sheet-steel galvanized-iron tubes 5 inches in diameter were provided for the 3-inch bolts and 4-inch pipes for the 2-inch bolts. The blocks turned to fit these pipes had been nailed to the under surface of the templet for holding the tops of these pipes in place. These tubes were then placed in position and their lower ends were built in with brick laid on top of the foundation washers. In setting these tubes care was used to get them centrally located with reference to the bolt holes in the washers and templet. After the tubes had been set the location of the templet was carefully checked.

The smaller and lighter bolts were located by hanging them in the templets, which were so built and supported that this could be done. Old 3-inch boiler tubes were rescued from the scrap pile, cut into 2-foot lengths and used to provide adjustment space at the top of the bolts. Newspapers were employed to center the bolts in the tubes and to prevent the concrete from rising in them.

This foundation was brought up and finished about 1¼ inches below the bottom of the bedplates. After the bedplates had been placed, lined up and leveled, the bolts were sufficiently set up to hold them in position, care being taken to avoid springing. The tubes around the bolts were then filled with fine dry sand to within a short distance of the top of the foundation. A dam was next built around each bedplate and the space below it with the tops of the tubes was filled with grout. Steel wedges made from 2x½-inch flat iron drawn down to a point under a steam hammer were used to raise the bedplate, the finished wedge being about 6 inches long. After the grout had set, the steel wedges were knocked out and the holes left were filled with pointing mortar. An ample supply of these steel wedges and 3x1-inch steel blocks for use as fillers below the wedges is a great convenience, especially when lining up heavy machinery. Hardwood, maple or oak wedges can be used with light machinery, but they are useless in working with machines having bedplates weighing from 40 to 50 tons.

Direct-connected sets, such as steam turbines and generators, motor-generator sets, rotary converters or well balanced reciprocating engines with generators can be mounted on structural foundations. Care, however, is necessary in the case of reciprocating units to insure that their cyclical period of vibration does not co-

incide with that of the supporting structure or is not a harmonic of it. When these cyclical periods harmonize the entire structure will be thrown into vibration. Should this occur the first remedy to be tried is slight alterations in the speed of the machine. A bucket of water should be set on the floor close to the machine and the vibration ripples on the water will show the effect of the changes in the speed. When it is impossible to cure the trouble in this manner, additions can be made to the weight of the machine by filling in the hollow portions of the bedplate with cement concrete. If enough weight cannot be thus added, a platform can be suspended under the machine in the floor below and a foundation built on it. The rods or bolts carrying this dead weight should be threaded to permit their load being clamped up solidly against the ceiling below the machine.

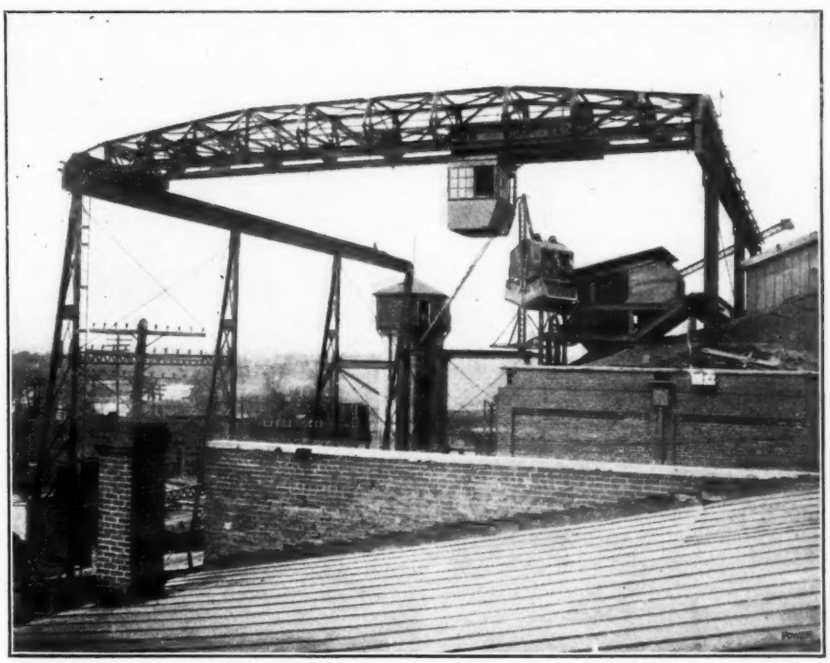
When properly constructed, a reinforced-concrete structure furnishes a favorable foundation. It is rigid and heavy and thoroughly tied together. Structural steel framing with concrete floor slabs makes the next best arrangement, particularly if care is taken to tie the steel frame with portal and "X" bracing. Tile or tile and concrete floors are not as good as heavy slab construction. The design of this type of foundation should not be lightly undertaken, as it is not a case where "most anything will do" and an improper design will result in trouble, perhaps a serious disaster.

Structural reinforced concrete, sometimes called steel concrete, is not the rough agglomeration it is sometimes imagined to be. Every piece of steel has its reason for being in the position assigned and no liberties can be taken without endangering the structure. Once there was a country millwright who read in the daily papers about reinforced concretes and saw some wonderful pictures of reinforced-concrete dams. It fell to his lot to build a small dam for the local authorities and it was decided to use reinforced concrete. So this millwright bought all the old horseshoes and scrap from the local blacksmith and mixed the mess with sand, cement and gravel and placed it in the forms. The life of this dam was very brief; in fact, it collapsed as soon as the forms were taken partly down, but, fortunately, before any amount of water had accumulated. Steel scrap mixed in the concrete does not act as reinforcing, and it is not wise to attempt a reinforced-concrete structure without competent advice.

Coal Handling at Muncie Electric Light Plant

By F. O. Whiting

In the American Gas and Electric Company's plant at Muncie, Ind., is installed a complete system for handling coal from the railroad cars to the stokers and for discharging the ashes from the furnaces. The railroad cars containing coal are run into the yard under a 70-foot span, open-girder type of crane operated on an elevated track approximately 70 feet from the top of the crane rail to the ground. This is shown in the illustration. The crane is equipped with a man-operated trolley from which is suspended a grab bucket having a capacity of 54 cubic feet, or about 1½ tons, and traveling at a speed of 250 feet per minute. By means of this machinery the coal is delivered from the cars at the rate of about 60 tons per hour either to the ground storage or to a traveling crusher located upon the roof of the boiler house. Here it is crushed and delivered into the overhead bunkers in the boiler house to be fed to the stokers at the will of the fireman.



Coal-handling Equipment at Muncie Plant

The bucket is of the four-rope type, using two ropes for closing the bucket and the other two for closing and lowering it. The operating mechanism for the bucket in the trolley is arranged so that the bucket is hung directly from three drums, the two holding ropes being fastened to the center drum and the two closing ropes to the outside drums. The closing drums are geared direct to a 50-horsepower series crane motor and the holding drum is geared to another motor of the same type and size, thus providing two motors entirely independent of each other for the manipulation of the bucket. These motors are fitted with solenoid-operated brakes and are controlled by means of a magnetic switch-control panel operated by a master controller which also operates the brakes and is arranged to give the following operations of the bucket:

One point of power on the closing motor with the brake released on the holding motor to allow the bucket to sink into the coal while closing.

Four points of power with both brakes released to hoist the loaded bucket, the two motors equalizing under the strain of the loaded bucket.

One off position with both brakes set for holding the loaded bucket while the crane or trolley is traveling.

One kickoff point with the holding brake set for dumping the bucket.

Four points on the dynamic brake for lowering the empty bucket.

As all the operations of the bucket are entirely controlled from one master controller, the operator has only three controller handles to manipulate when operating the crane; these are: the bucket controller handle, the trolley controller handle and the bridge controller handle.

The weight of the trolley complete with the loaded bucket is approximately 25,000 pounds and it is driven along the bridge by a 10-horsepower series crane motor. The traveling crane is propelled in either direction at a speed of 300 feet per minute by a 25-horsepower series motor. This motor is fitted with a solenoid brake for bringing the crane to rest, also for holding it against the effect of weather conditions.

The bridge and trolley controllers are fitted with a special point on either side of the off position, which cuts off the power from the motor without releasing the solenoid brakes and allows the crane to drift before coming to rest.

The coal is delivered to the plant in the run-of-mine size, and a Jeffrey single-roll crusher reduces it to stoker size. This crusher is mounted on a steel framework placed on four 12-inch double-flanged truck wheels which run on a track the full length of the boiler house. It is equipped with a receiving hopper holding about three bucketloads of coal and is belt connected to a 20-horsepower shunt motor. The coal is delivered through openings in the roof to the overhead bunkers in the boiler house and the crusher is then moved along the track by placing the grab bucket alongside the hopper and moving the traveling crane in the desired direction.

The plant has a capacity of approximately 3200 boiler horsepower, being equipped with eight Stirling boilers of 400 horsepower each; these are fitted with chain-grate stokers. The capacity of the overhead bunkers is approximately 500 tons of coal.

Under each grate are two hoppers; that under the forward end being the reclaiming hopper, which is used to catch the unburned coal falling through the grate and which is fed again to the stokers. The ashes are dumped over the rear end of the grate into the ash hopper where the contents are discharged into small dump cars which carry them out of the building through an underground passage to a concrete ash hopper located in such a position that the ashes can be reclaimed by the bucket and discharged into railroad cars for shipment by rail.

The Steam Turbine in Germany

By F. E. Junge

Increased reliability of the steam turbine. Steel, brass and bronze as blade material, condenser tubes and turbine foundations.

Since the fuel economy of steam turbines has reached a figure which will not be greatly surpassed in the near future, the attention of designers has been divested to increasing the output or capacity in order to effect economies in floor space, weight, construction, attendance and other items, the aggregate of which is superior in importance even to the fuel consumption. It is interesting in this connection to note that the capacity of Allgemeine Elektricitäts Gesellschaft turbines has increased between 1904 and 1911, for the 3000-revolution type, from 1250 to 4400 kilowatts; for the 1500-revolution type from 3000 to 11,800 kilowatts; for the 1000-revolution type from 5000 to 21,400 kilowatts per unit. The 20,000-kilowatt unit is the largest built on the European continent today.

Such an increase has been made possible by a corresponding increase in operating reliability of steam turbines. To install a 20,000-kilowatt unit as the sole source of power in an industrial establishment or central station without any provision for reserve—except such as is offered by connection to an overland line—would be impossible if the probability of breakdown was not now almost entirely eliminated. Much of the earlier trouble was due to a lack of understanding of the relative merits and qualities of materials employed in the different parts of the turbine and condenser. Other troubles were due to unclean steam, to poor foundations, to unreliable auxiliaries, etc. As to some of these problems, O. Lasche, chief engineer of the steam-turbine department of the Allgemeine Elektricitäts Gesellschaft, of Berlin, has just communicated the results of his experience to the *Verein deutscher Ingenieure* for publication, and the following is an extract from his views.

Blade Material

The material employed for blades in the first stage which has to deal with high pressures and temperatures is for the most part nickel steel. The temperatures and blade lengths occurring in the following stages permit the employment of brass, while the long blades of the last wheels necessitate the employment of a special bronze. These three materials, each used exclusively within its own temperature range, give together complete satisfaction for all conditions under which steam turbines nowadays have to work; but in order to ascertain these respective limits the chemist and metallurgist had to come to the aid of the engineer and designer, since the old methods of testing materials were no longer sufficient. By far the simplest of all materials with respect to analysis and determination of characteristics is brass. Its use is governed solely by factors or terms which are well known or can be ascertained by easy methods of test. Its resistance to rupture, relative elongation, flexibility and hardness in cold and heated condition, are all known, so are the results of the impact or drop test on notched bars. The numerical values of the various items are graphically shown in Fig. 1. Brass retains its full tensile strength up to 200 degrees Centigrade (418 degrees Fahrenheit). The figures for bronze are considerably higher, and the behavior of nickel steel, especially when it contains a low percentage of

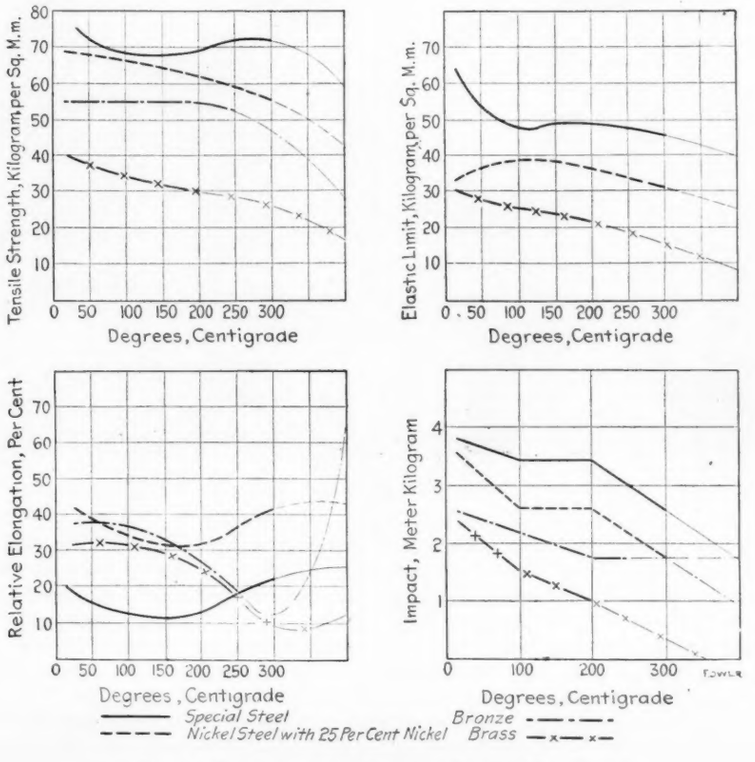


Fig. 1. Properties of Various Blade Materials

nickel, is even superior to that of brass. The numerical values of the yield point correspond, approximately, to the above, while the curves for the relative elongation for the different materials and temperatures intersect at various points. The determination of the limits within which elongation is still permissible is greatly facilitated by the results of the impact test.

Less simple is the correct determination of the lower and upper limits of hardness of blade materials. A certain

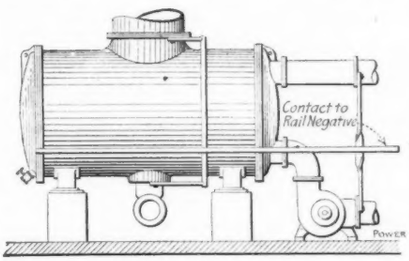


FIG. 2. CONNECTIONS TO AVOID ELECTROLYSIS

surface hardness is necessary in order to provide against the erosive action of the steam. On the other hand, if the material is too hard its tendency to fracture becomes so great that it is no longer suitable for blades. Especially is this the case if the hardness of the material is caused by cold-drawing of the metal. The following are considered good mean values for hardness: Brass, 100; bronze, 125; nickel steel, 150 to 200. The composition of the brass alloy is 72 copper, 28 zinc, with permissible traces of lead. This compound metal is employed successfully up to 400 degrees Fahrenheit for blades, and for distance pieces and shrouding up to almost 600 degrees Fahrenheit. The limits for blades is set lower because there is an additional heating of the surface through steam friction, which can hardly be measured. A noteworthy feature is the capability of resistance of brass to the action of steam which is chemically impure. Bronze is used for blades on account of its superior hardness and its high tensile strength.

When the Curtis wheel was first adopted by the Allgemeine Elektricitäts Gesellschaft people there was a general belief prevalent among German manufacturers that the high speed of the impinging steam would quickly destroy the blades of the first row, but the advantage of employing high steam temperatures and yet having low temperatures in the turbine casing was so great that the majority of builders have adopted the combination. Since the limits within which the different blade materials are preferably used have been ascertained there has been no more trouble with the blading, and there are a number of turbines in actual service which, after 25,000 operating hours, show no sign of increasing steam consumption.

Much of the former trouble was due to impurities in the steam. Deposits from the boiler, driven by the heat into hard and granular particles of dust, caused a rapid wear of the sharp inlet edges or cavities of the blades. These troubles, of course, never occur in turbine-driven central stations where the condensate is used for feeding purposes. It is just as much in the interest of the boiler equipment as in the interest of the life of the turbine to insist upon the use of pure feed water. If this precaution is taken there is no fear of any considerable wear of the blading for several years.

A second method of failure observed was due to the outer skin of the bronze blades showing a tendency to jar off at excessive temperatures, while with nickel steel and brass this kind of wear never happened. Therefore, the upper limit of temperature for the employment of bronze blades was set at about 400 degrees Fahrenheit, though the decomposition of the material does not actually begin until at almost 600 degrees. This is proved by the fact that the nozzle heads of Allgemeine Elektricitäts Gesellschaft turbines, which in many installations are exposed to the full steam pressure of 12 atmospheres (176 pounds per square inch) and to temperatures of 300 degrees Centigrade or 600 degrees Fahrenheit, are in perfect condition after 25,000 operating hours.

In contrast to brass there are bronzes of great tenacity and strength, which, on account of a small admixture of aluminum, are subject to chemical reaction within certain temperature ranges. These alloys must be avoided in plants where the feed water contains magnesium chloride or calcium chloride or ammonia. Chemical decomposition does not, however, begin at temperatures of 400 degrees Fahrenheit, but rather within the range of saturation, namely, between 130 and 70 degrees Centigrade (266 and 158 degrees Fahrenheit), while below this limit signs of decomposition were not apparent. Contrary to the destruction of blade material through high temperatures or mechanical effects, the chemical decomposition of materials is less marked at those places which are constantly impinged by the steam jet than at others where the steam adheres to the solid particles of sediment carried in.

Nickel steel of various compositions has been employed for high-pressure blades since 1907. Blade fractures—most of them in the full cross-section of the material—did occur at parts which were subject to stress as well as at others which were not. After some experimenting the Allgemeine Elektricitäts Gesellschaft has succeeded in finding an alloy of nickel steel, the composition of which is not given, which is used for the guide diaphragms in all pressure stages and at all temperatures, and has given complete satisfaction in six years' service. As blade material a steel with 5 instead of 25 per cent. nickel is being used. A low percentage of nickel makes a better material than a high percentage, especially when the carbon content of the steel is low, and a small percentage is sufficient also to protect the blades against rusting. Summarizing the foregoing, it is seen that brass occupies by far the foremost place as blade material, the limits of its adoption being fixed by its tensile strength, which can easily be ascertained in its cold and heated condition. Above this range a suitable nickel steel finds its field of usefulness, while below it a bronze of great strength gives satisfaction.

CONDENSER TUBES

The principal condition for continuous service is a sufficiently soft material. The occurrence of transverse fractures or longitudinal cracks is due exclusively to faulty manufacture and hardness of the metal. Another cause of destruction of condenser tubes consists in the decomposition of the tubes from within, whereby the material is gradually eaten up all along the inner surface. There remains a thin film of solid material which cracks on some occasion. It is peculiar that those tubes which contain the warm

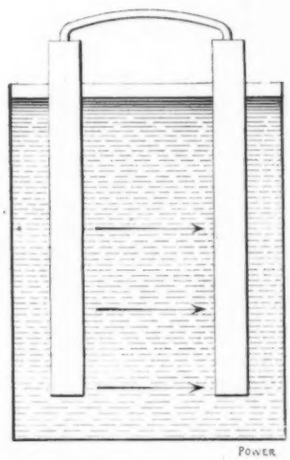


FIG. 3. VARIOUS METALS PLACED IN SEA WATER

water are more easily affected than those through which the cold water flows. This rotting of the whole material is largely due to the chemical action of the cooling water, especially if acid mine water is used or water which contains ammonia. These harmful effects can at times be neutralized by adding chemical compounds to the water.

There is a third kind of destruction of condenser tubes, the cause of which is not so easily ascertained as in the above cases. It occurs frequently when sea water is used in the condenser and exhibits itself in the form of corrosion starting from within. This mode of cor-

rosion has given rise to the thought that an alloy which is not quite uniform in composition contains in itself infinitely small galvanic elements; but trials made with various alloys in sea water for a year have not so far given evidence of the correctness of this assumption. Likewise it was not proved that an addition of 1 or 2 per cent. of tin to the zinc-copper alloy meant an improvement of the material, or that there is an advantage in providing brass and copper tubes with a coating of tin, nor, finally, that pure copper tubes or those consisting of an alloy of brass with an admixture of 70 per cent. copper were superior to the same alloy with only 60 per cent. copper.

In power stations which are located on the seashore, using sea water for the surface condensers, and which supply current for electric railways, or in plants which are situated in the neighborhood of such roads, there are potential differences of several volts, due to stray currents, measurable between the metallic bodies of the plant. These currents can be eliminated by short-circuiting through a heavy cable, and, if necessary, by connecting the condenser with the negative rail of the road, as shown in Fig. 2. It is known also that the metals used about a steam plant, such as aluminum, zinc, iron, tin, brass and copper, are attacked by galvanic currents as soon as they are brought into metallic contact with each other. These currents flow in the manner shown in Fig. 3 from any one of the materials named in the above series to any named later in the list, and back through the water as indicated in the sketch. The material from which the current passes into the water is destroyed through this process. In order to avoid this kind of destruction of condensers it has become the practice to provide protecting plates of zinc and aluminum, the zinc plate forming the electropositive part of a galvanic element, which is destroyed through the generation of the electric current. With this precaution taken, decomposition of tubes can occur only when the bottoms of casings or tubes consist of an alloy containing a high percentage of copper. These researches for the causes of condenser trouble are to be continued by the Allgemeine Elektricitäts Gesellschaft.

The chief advantages of surface condensation, next to superior operating reliability, consist in a low demand for power, and in the regaining of the condensate as practically pure feed water without the purifying devices which are used with reciprocating engines for separating the oil. The rapid introduction of surface condensers for land work consequent upon the development of the steam turbine naturally involved new problems which required some experience for their solution, but this experience is now available and there is no fear of new surprises.

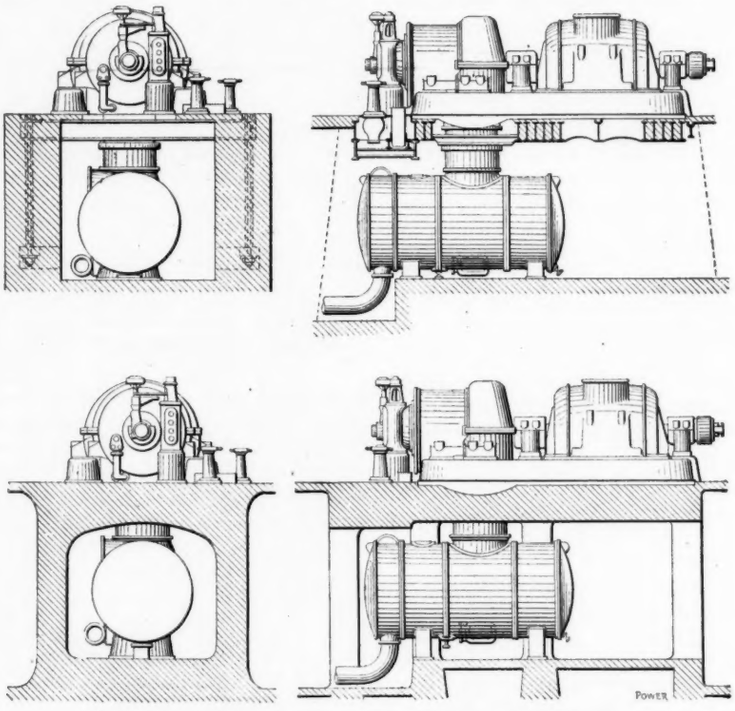


FIG. 4. TURBINE FOUNDATIONS—OLD AND NEW METHODS

FOUNDATIONS

With turbines of 20,000 kilowatts capacity, having movable parts weighing 50 tons which revolve at high speed, it becomes of paramount importance for the operating reliability of the plant to provide absolutely rigid foundations. Even though the revolving masses are nicely balanced, there may occur vibration at one point or another of the system when the foundation is soft or elastic, and when the fixed masses of the unit do not correspond to the movable ones. Fig. 4 gives a comparison of turbine foundations built on the old and new methods.

The old way was to erect brickwork pillars, connect them by means of I-beams on top, and to fill the hollow spaces between them with a mixture of cement, sand and stone. This filling, however, did not always give a satisfactory connection between foundation frame and beams.

The new way is to erect a heavy concrete structure, which is solid throughout, with an arched vault on top, which serves as a receptacle for the condenser and as a base for the turbine. This concrete foundation, if properly constructed, is rigid, and affords the best possible rest for the frame plate. Of course, changes such as would be necessary if the plant was to be enlarged are very difficult to make; and provisions for probable changes should be made when laying out the plant. But the main thing is that the frame plate, which in former times was subject to being bent and brought out of alinement when tightening the holding-down bolts, now finds a rigid base upon which to rest and in turn affords a true base for the various detachable parts of the turbine.

Dr. H. Loebell, in the *Chemical Trades Journal*, warns against too hasty condemnation of a lubricating oil because of deposits which occur in the cylinders, bearings, etc., where it is used. An examination of the deposit should always be made before resorting to an exhaustive examination of the oil. If the deposit dissolves for the most part in benzole (or chloroform), a complete examination of the oil is called for, and in particular it should be examined as to its tendency to resinify, using Kissling's method. But if the greater part of the deposit resists solution by benzole (or chloroform), the original oil need only be examined at first as to its constituents insoluble in benzine. If the original oil is found to be almost completely soluble in benzine, there is no sufficient ground for abandoning its use. The probability is that the deposit has some other origin; in fact, in some cases it may be found to consist of inorganic matter (largely silica and silicates) holding, like a sponge, unethered or partially resinified oil. The parts of the machine and lubricating appliances should be cleaned and a fresh start made. Should a gummy deposit mostly soluble in benzole result this time, the original oil calls for investigation as to its tendency to resinify, using Kissling's method. A word of warning is issued as to paying too much attention to the reports of greasers whose "palms may have been oiled."—*The Engineer.*

Waste of Power in Unalined Shafting

By H. Prime Kieffer

Some results of tests to determine the alinement of shafting in various important manufacturing establishments, showing bad conditions prevailing.

Great savings in friction load effected by realinement.

A poorly hung line-shaft wastes much more coal than is usually realized. Many of the best authorities have declared that the greatest waste of power in the average manufacturing plant is due directly to the poor alinement and level of the line shafts. Up to about two or three years ago there was no practicable method of determining the exact condition of the line shafts and of making them correct. Today, however, there is such a device and hundreds of progressive plants are cutting down a big item of waste.

In this connection it is surprising to see how little the executives of a company know about the power conditions. They do not go over their line shafts any more than is absolutely necessary to keep them up. I have found in any number of instances plants that have not had their shafts gone over in three years. The hundreds of tests of the condition of line shafts in manufacturing plants which the Kinkead Manufacturing Company has conducted have opened the eyes of many factory managers and the experience gained in this matter should be of interest to all mechanical men.

In a certain large shoe manufacturing concern it was found that the shafts were all in a bad state, varying from 2½ inches out of level, to 1¼ inches out of line. This was on shafts about 100 feet long and from 3 7/16, to 1 15/16 inches diameter. It was taking 85 horsepower to turn the shafts with all belts on but no work being done on any of the machines, while it took approximately 125 horsepower on full load, or 68 per cent. friction load. This shoe company has three factories within a radius of fifty miles and it would pay it very handsomely to line up the shafts of the different plants with a modern appliance. This need be done only two or three times a year at a very small labor cost, and the shafts kept nearly correct.

Another point which is frequently brought up is the varying floor load and its influence on line shafts. A series of tests was made in one of the largest manufacturing plants in this country to determine this effect. The lines were found to be in very bad condition. The buildings were of heavy mill construction and the argument was advanced that the condition of the shafts was due to the changing loads, shrinkage of timbers, settling of the building, etc. To prove that such was not the case, two lines were put in absolutely correct condition with the Kinkead device and the hangers fastened very securely. Then the floor loads above, and especially those around the floor columns, were all changed both as to position and weight. Where the shafts had previously been out of line as much as 1⅞ inches and out of level as much as 3½ inches, after rearranging the loads and waiting thirty days, at no hanger was the line out as much as ¼ inch either way. Monthly readings showed that this condition remained practically the same and it was but a few moments' work to change the hanger which was getting out of line and level. The idea that the bad alinement of shafts is due primarily to changing conditions in the plant is nothing in the world but a fallacy.

As far as time of doing the work is concerned, it is remarkably short, so much so in fact, that it is always necessary to actually conduct some tests before people will believe that the work can be done so rapidly. In the case of a plant in Indianapolis, at five minutes to twelve the superintendent took an ammeter reading on a 65-foot shaft, and found that it was requiring just 15 amperes at 110 volts to turn the shaft. All belts were on but no work being done on the machines. The line shaft was literally covered with pulleys, clutches, collars, etc., so that it would be almost impossible to level this shaft with the ordinary carpenter's level. Yet in 55 minutes the shaft was put into perfect line and level without having removed a belt, and when the shaft was run for five minutes after one o'clock, it took just eight amperes continuously on friction load, or almost 50 per cent. reduction immediately. The shaft was not nearly as bad, as far as line and level was concerned, as is found in nine out of ten plants.

In another instance, that of a paper mill where they were having trouble with a line shaft placed on concrete piers, the line being 260 feet long, the shaft was found to be 3½ inches out of level from end to end and as much as 1⅞ inches out sideways, with big jumps at each successive hanger. With all belts and pulleys on, that shaft was lined and leveled absolutely true in five hours. This was in a dark room too, but the work was made easy by the illuminated targets employed. The general superintendent stated that it usually took the men a full week to get the line in what they thought was "good shape."

Most managers and other officials will be especially interested in tests to determine the exact amount of saving due to lining and leveling their shafts. It can be stated specifically that a saving on each line shaft of from 10 per cent. to 50 per cent. of the friction load which that line takes can be guaranteed. Of course, there are a number of elements which govern the amount that the line is requiring, such as length, diameter of shafts, distance between hangers and, of course, the amount that the line is out of true, as well as how firmly the hangers are set. As an illustration of the conditions found in the average plant, a few readings taken at random from over a thousand are given. Many companies are now vitally interested in this matter of shaft alinement and have regular inspectors who attend to it, taking motor readings at stated intervals and keeping the line in perfect condition.

FIG. 1. SAMPLE REPORT OF SHAFT MISALINEMENT TEST

Outfit No. Date *March 1st*, 1911

Name

Address *Auburn, N. Y.*

M.M. Dem.

Hanger No.	High	Level	Low	North-east	Line	South-west
1			3 1/16"		*	
2			3 1/16	1 1/16"		
3			3 1/16	1 1/16		
4			2 15/16	1 15/16		
5			2 15/16	1 15/16		
6			2 15/16	1 15/16		
7			2 15/16	1 15/16		
8			2 15/16	1 15/16		
9			1 15/16	15/16		
10			1 15/16	1		
11			1 15/16	1 1/16		
12	1/16"			1 1/16		
13	1/16			1 1/16		
14	1/16			1 1/16		
15		*			*	

These 3 columns deal with the level of shaft. 10 *feet between hangers.*

These 3 columns deal with the alinement of shaft.

FIG. 2. SAMPLE REPORT OF SHAFT MISALINEMENT TEST

Outfit No. Date *Dec.* 18, 1908

Name

Address *Waltham, Mass.*

M.M. Dem.

Hanger No.	High	Level	Low	North-east	Line	South-west
1			2 1/16		*	
2			1 15/16	1/16		
3			15/16	1/16		
4			15/16			3/16
5			1/16			1/16
6			1/16			1/16
c7			1/16	1/16		
8			1/16	1/16		
9			1/16	1/16		
10						
11		*			*	

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

Pulley Faces and Belt Speeds for Medium Speed Motors

By H. M. Nichols

The accompanying table gives the belt widths and speeds and the corresponding pulley-face widths that are usually employed for motors running at medium speeds.

PULLEY FACES AND BELT SPEEDS
For Medium Speed Motors

Horsepower	Width Belt	Pulley Face	Belt Speed in Feet per Minute
1 to 4	2″	2½″	2000
5 to 10	3″	3½″	2500
10 to 15	4″	4½″	2500
15 to 20	5″	6″	2500 to 3000
20 to 25	6″	7″	3000
30 to 40	8″	9″	3000
40 to 50	10″	11″	3000
50 to 60	12″	13″	3000 to 3500
60 to 75	14″	15″	3500
75 to 100	16″	17″	3500 to 4000
100 to 125	16″	17″	4000
125 to 150	18″	19″	4000 to 4500
150 to 200	20″	21″	4500

Starting Rotary Converters from the Direct Current Side

By Leonard Freed

The starting of rotary converters from the direct-current side involves certain difficulties, depending a great deal upon the inherent characteristics of the machine itself. To start a converter from the direct-current side, it must be treated as a shunt-wound motor; therefore, if the machine is compound-wound it will be necessary to short-circuit the series field winding or else use the equalizer lead for starting, in order to leave the series field winding out of circuit. If the series winding were left in circuit, the machine would be differentially excited and the starting current would be very large, due to the weakening effect of the series field winding.

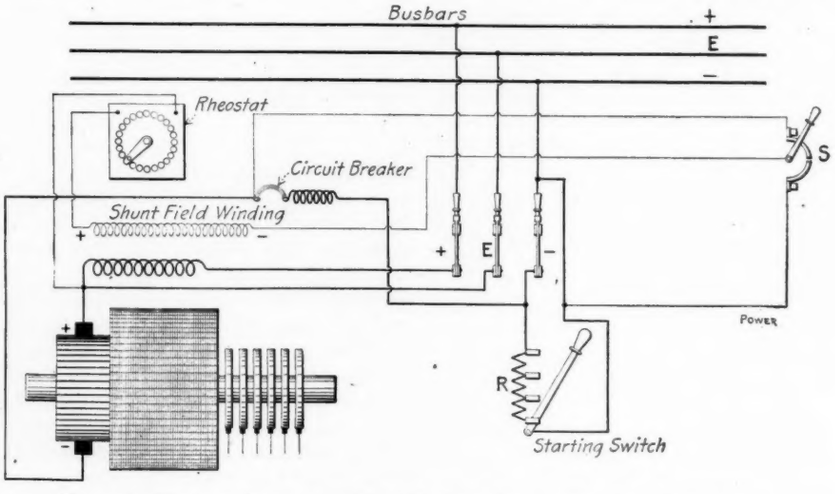
The accompanying diagram shows the connections used for starting a 1000-kilowatt 600-volt converter in a certain plant. A special feature of these connections is the single-pole double-throw field switch *S*, which is constructed in such a manner that one contact cannot be opened until the other one is closed. The object in providing this switch is to obtain full field excitation during the starting period and to maintain full excitation should the main circuit-breaker open. Without this switch, the voltage drop in the starting resistance would reduce the field excitation if the field circuit were connected directly to the direct-current brushes, or, if the field circuit were connected outside the starting resistance, the opening of the circuit-breaker would disconnect the negative field terminal from the negative brush and prevent the machine from exciting itself. In the latter case the machine would be left running as an induction motor, taking a large lagging current at the alternating-current side. In order to excite the converter from the busbars in the ordinary way it was found that the design of the converter panel and general layout of the switchboard would have to be changed about to prevent the field circuit of the converter from being broken after the machine was in service, by the opening of the circuit-breaker; hence the arrangement here shown was adopted.

In starting up, the negative field lead is connected to the negative busbar by closing the switch *S* downward. Then the equalizer switch is closed, connecting the positive brush and positive field terminal to the positive busbar and thereby exciting the field. All resistance is then cut out of the field circuit by means of the rheostat, and the starting switch *R* is closed in the first step, as shown in the diagram, starting the machine as a direct-current motor. The starting switch is closed gradually as the machine speeds up and when all the resistance is cut out the main negative switch is closed and the starting switch *R* opened wide. When synchronous speed is indicated, by synchroscope or lamps, the alternating-current switches are closed in the usual way.

With the field connections as described, it is obvious that if the circuit-breaker or negative switch were opened, the field circuit would be dependent on the busbars for exciting current and if it happened that the other machine or machines had also thrown their circuit-breakers the field circuit would be dead. To avoid this, the switch *S* is closed upward, connecting the negative field terminal directly to the negative commutator brush. Then the positive switch is closed and the load adjustment made in the usual way.

A large rotary converter connected to the transformers while starting on the direct-current side (the transformer primaries are not connected to the supply circuit, of course), takes a considerable starting current, owing to the fact that the converter armature is practically short-circuited through the secondary windings of the transformers. In some cases it is found advisable to disconnect the secondary transformer leads at starting, by means of switches in the leads.

Varying voltage at the direct-current busbars sometimes causes trouble in syn-



Connections for Obtaining Full Excitation under All Operating Conditions

chronizing. If the voltage changes suddenly just as synchronism has been obtained and the operator is in the act of closing the switch to connect the alternating-current supply circuit, this will usually change the speed of the converter, throwing it slightly out of phase and causing a large rush of current between the alternating-current and direct-current sides of the machine, possibly causing the brushes to flash over. When a storage battery is floated on the busbars, this condition is avoided and it is an easy matter to synchronize a converter started on the direct-current side, because there is a steady voltage at the busbars.

CORRESPONDENCE

Quick Repairs on a Pitted Commutator

Some time ago I was employed as electrician for a hydraulic mining plant where the centrifugal pumps used were driven by 500-volt direct-current motors. A large motor (100 horsepower) became splashed with water on one occasion and the results of the splashing were some not serious looking pits in the mica strips between the segments of the commutator—pits in which it would have been possible, perhaps, to put the head of an ordinary pin.

However, as the machine continued to run, carbon dust from the brushes filled these pits. This formed a carbon bridge across the mica from segment to segment, and in due season the electric current would travel across this bridge, burn the bridge behind it, destroy some of the nearby mica and carbon, and then things would run along as before. Each time this happened the pits were increased in size, and also, as was to have been expected, the explosions due to a further accumulation of carbon became rarer but more destructive. At length the flame from the arc formed at the time of one of these explosions became so large that it would sweep clear around the commutator and establish short-circuits from brushholder to brushholder. This would open the 600-ampere circuit-breaker which took care of that part of the electrical system and profit taking would be stopped for some minutes. By this time the pits were considerably enlarged; they would have held a cough drop without impressing an observer that the situation was at all cramped.

Quick repairs were in order, so I decided to go to the nearest town, about eight miles away, and try to get a suitable filling for the pits. After some thought I decided to try to use the same cement employed by dentists, which consists of a putty made of glacial phosphoric acid and oxide of zinc. There was a dentist in the village who proved to be very willing to help out. He sold me for a trifle the quantity of the ingredients needed and also gave me full directions for mixing and handling.

In preparing to make the repairs, I first cleaned out the pits to receive the fillings. Knowing that the centrifugal force tending to throw out such a mass of material was very great, I made the bottoms of the pits larger than the openings. To enlarge the bottoms of the pits I upset the end of a small piece of steel rod ⅛ inch in diameter, until it had a sort of head on it about 3/16 inch in diameter, and filed some cutting edges on this head, making a tool somewhat like a rose countersink. After hardening the piece I used it in a common breast drill to ream out the bottoms of the pits.

Following the dentist's directions, I made the putty by pouring the acid on the pulverized oxide of zinc until the resulting mixture was just soft enough to be kneaded between the fingers. I packed this mixture into the pits solidly, leaving it high enough above the general surface to permit a good smoothing down with sandpaper after it had hardened. In about two hours it had set hard; I then sandpapered it well and started the machinery. The motor never gave any more trouble in the eight months subsequent to this, which was the length of time during which I had it under further observation, and the fillings never cracked in the slightest degree; neither did they wear excessively or appear to do the next most objectionable thing—wear too little and thereby cause the brushes to jump when passing over them.

J. O. BARNWELL.

Pasadena. Cal.

The Manager Gets Some Experience

The manager of a certain electric-lighting plant was long on managing ability but short on practical electrical experience. He knew enough about it to wire up sockets, fan motors, etc., and frequently came down to the station and spent an hour or two tinkering around at some such work.

He came into the station one evening and proudly exhibited to the engineers a fine new pair of nickel-plated pliers which he had just purchased, remarking that when it came to pliers he guessed that none of us had anything on him. Before leaving, he remarked that he wanted a socket and a few feet of lamp cord to wire up another drop light in the office. The engineer pointed to a drop light in one corner of the engine room which was not in use, telling him to cut it off as far above the socket as he liked and take it along for the purpose. While this lamp was not in use, it was still connected to the circuit through a fuseless rosette, the cord, of course, being "alive."

The manager took a chair and started over to get it. Climbing upon the chair, he reached up and took hold of the cord with his new pliers; but instead of separating the two cords and cutting one at a time, he cut them both at once. There was a loud snap, a blinding flash, and the manager, chair and all came down onto the floor in a general mix-up. He got up, eyed his ruined pliers sadly and remarked: "Well, any d——d fool that don't know any better than to do a trick like that ought to get killed anyhow."

SAMUEL KIRLIN.

New York.

Mr. Edge's Wiring Pointers

In his article, "Practical Points on Electric Wiring," published in the September 12 issue, Mr. Edge seems to ignore the fire underwriters' requirements. For example, a snap switch should not control more than three lamps; further, the two-light circuits in Figs. 4 and 5 are shown without any fuses, which would not be allowed.

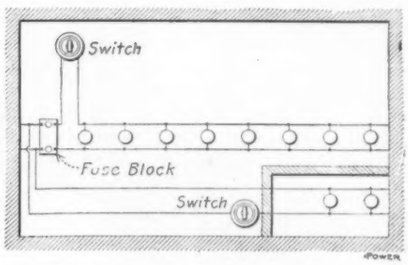


FIG. 4.

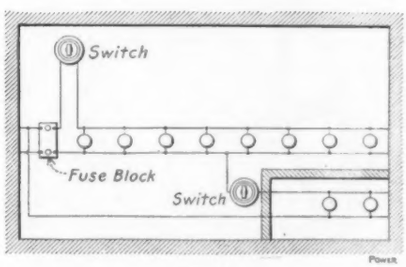


FIG. 5.

His paragraph on grounding conduit is rather restricted and vague. There are well defined rules for grounding a conduit correctly.

E. ROPETER.

Pottsville, Penn.

Bags are caused by overheating portions of the sheet while under pressure. Sediment, mud or masses of scale settle on the sheet, preventing access of water and the metal, being softened by the heat, yields to the pressure and stretches into the form of a pocket or bag. It can be prevented by keeping the boiler clean.—*Ex.*

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

Sargent Combined Gas Engine and Air Compressor

With the increasing demand for compressed air for industrial purposes and its economical compression in large or small quantities, there have been many improvements and refinements in compressors which have increased their efficiency and reliability, yet the thermal and volumetric efficiency of many air compressors is still too low. Moreover, on account of the high cost of electric power and low mechanical efficiency of compressors belted from gas engines, air compression on a small scale is not feasible in many cases where it would otherwise be employed. It was with these

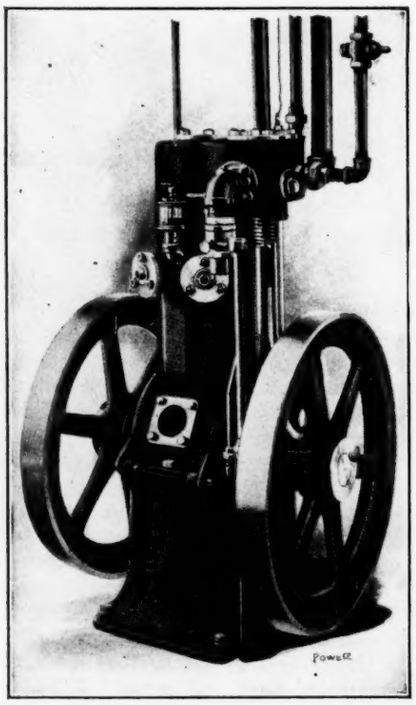


FIG. 1. COMBINATION ENGINE AND COMPRESSOR

conditions in mind that the self-contained gas engine-air compressor illustrated herewith was designed. It consists of a vertical gas engine with a differential trunk piston, the larger diameter of the piston being used for compressing air in the annular space around the smaller trunk. As there is but one piston structure, one connecting rod, one crank and one shaft for both the gas engine and the compressor, the mechanical efficiency of the unit is naturally high.

On the upstroke, air is drawn into the crank case through the port *K*, Fig. 2, when it registers with a corresponding port on the crank disk *J*. On the downstroke, air is compressed in the crank case and flows through the automatic valve *E* into the annular chamber around the trunk of the differential piston. On the return stroke this air is forced through the automatic outlet valve *H* and outlet *I* to the storage tank or receiver; during this stroke the crank case is again filled. On account of the large surface surrounded by cold water and the short distance the heat has to travel when generated in the annular space by compression, it is said, the thermal efficiency should be higher than in compressors

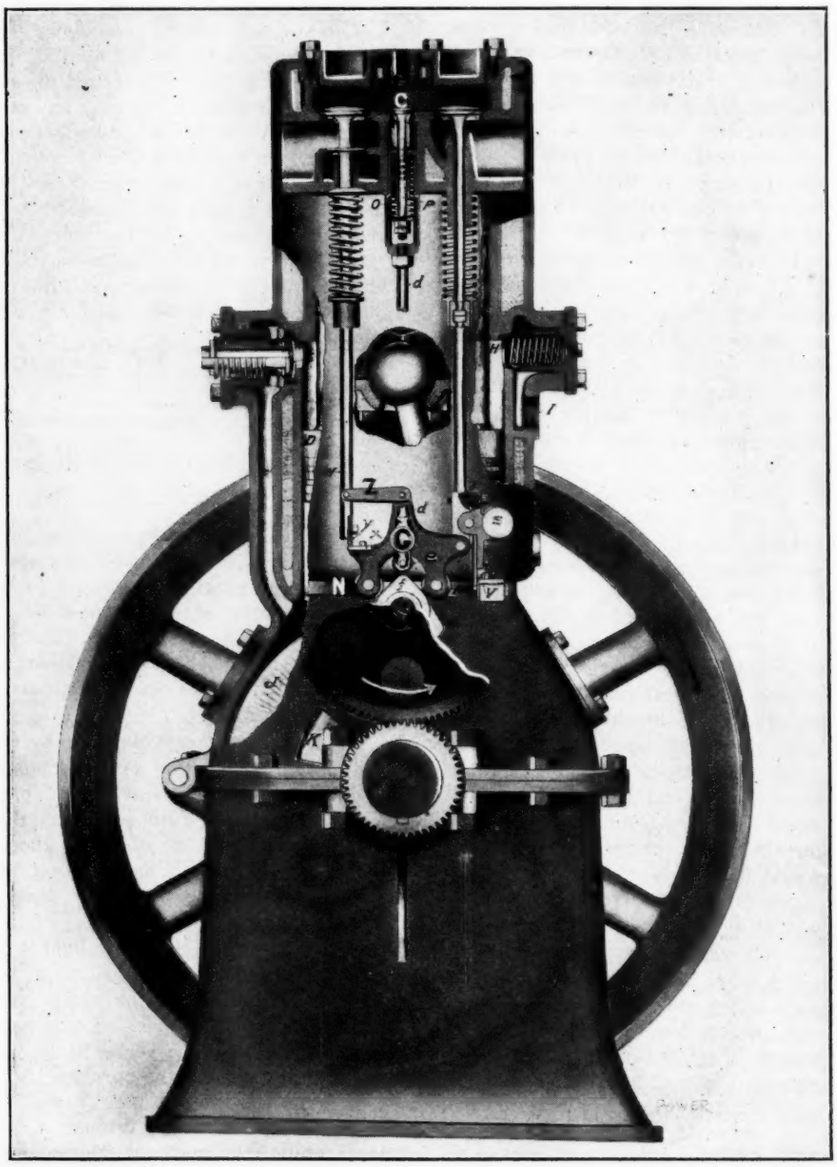


FIG. 2. VALVE MECHANISM AND CYLINDER CONSTRUCTION

having a small cooling surface per unit of volume.

As the pressure is always downward, a clearance of 1/100 of an inch is said to be maintained easily, and discharge pressures of from 60 to 140 pounds, obtained with high volumetric efficiency. The upper end of the connecting rod is a large steel ball; therefore the piston and rings may revolve and produce uniform wear of the cylinder wall.

The engine works on the four-stroke cycle and as air is compressed on every stroke the two flywheels and crank disks are made heavy in order to maintain a sufficiently uniform speed. The valve gear is highly ingenious. A cam *L* on the half-time shaft oscillates a rocker yoke pivoted on the stud *G* and thereby opens the inlet and exhaust valves successively. When the cam strikes the roller *M*, the exhaust valve *B* is lifted; a quarter of a revolution later it engages the roller *N* and lifts the admission valve *A*, a link *Z* from the valve rod *W* to a

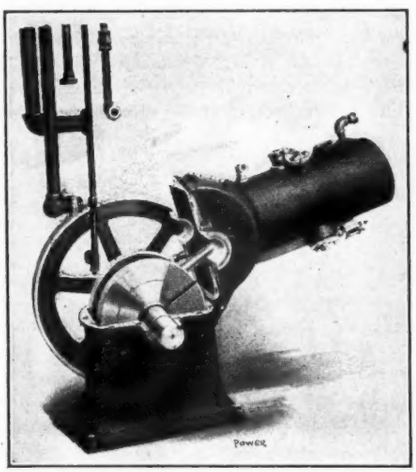


FIG. 3. OPEN FOR INSPECTION

vertical arm of the rocker yoke holding the blade *Y* in the path of the block *X*. Should the speed exceed the normal rate, the inertia weight *S* will lag behind the exhaust-valve rod in its downward travel and pull the blade *U* to the right where it can engage the plate *V* and hold the exhaust valve open. This also holds the rocker yoke tilted in such a position that the link *Z* pushes the blade *Y* out of reach of the block *X* and prevents the inlet valve from being opened when the cam *L* engages the roller *N*. The next time the cam *L* engages the roller *M*, if the speed has fallen to normal the governor weight *S* does not lag behind the valve rod in falling, and the blade *U* misses the plate *V*, allowing the valve gear to resume normal operation.

Either gas, gasolene or kerosene may be used for fuel. When gas is used it is admitted through a graduated valve to the space *R* from which it flows to the explosion chamber with the air when the supplementary disk *Q* on the admission-valve stem rises. Gasolene or kerosene is taken in through a mixing valve on the air pipe, shown in Fig. 1.

Compressed air from the storage tank filled by the compressor is used for starting. It is admitted through the valve *C* which is positively opened at the beginning of each working stroke as long as compressed air is turned on and the pressure is greater than that in the combustion chamber. The valve rod *d* passes through the end of the stud *G*, which serves as a guide for it, and carries at its lower end a roller *e* located in the path of the cam *f*. When the cam lifts the rod it merely relieves the spring pressure on the valve stem *O*, allowing the air pressure to open the valve if the internal pressure will permit.

The crank pin is accessible through the handhole plates, or the piston rod and crank may be adjusted or removed by turning back the cylinder on a hinge, as shown in Fig. 3. Ignition is effected by jump spark; the primary circuit of the induction coil is closed once in two revolutions by a pin on the secondary gear.

Compressors of this type will compress air to 200 pounds gage or to any lower pressure at which unloader is set. This outfit was designed by C. E. Sargent, 136 West Lake street, Chicago, Ill.

The Heat Equivalent of the Condensate from a Gas Calorimeter

BY J. ALBERT M. ROBINSON

There are various means of determining the heat value of the condensate or drip from a gas calorimeter. The method herein described is one not commonly in use; it is based upon the assumption that when the gas is burned, the water vapor it contains is condensed and lowered in temperature from 212 degrees to the temperature of the issuing products of combustion.*

The accompanying table gives the heat content of 1 to 10 cubic centimeters of condensate, at temperatures from 35 to 100 degrees. For any other quantity of condensate than those stated, the heat content may be found by direct proportion.

EXAMPLE

For one cubic foot of producer gas burned in a calorimeter, the average temperature of the exhaust gases was 70 degrees, and the quantity of condensate was 6 cubic centimeters. The gross or high heat value of the gas was 136.8 B.t.u. as metered. Required, the net or low heat value of the gas as metered.

From the table, in the 70-degree line and in the column under 6 cubic centimeters, the heat content of the condensate is found to be 14.7 B.t.u. Therefore,

$$136.8 - 14.7 = 122.1 \text{ B.t.u.}$$

low value, as metered.

TABLE FOR DETERMINING THE HEAT EQUIVALENT OF THE CONDENSATE FROM A GAS CALORIMETER—BRITISH THERMAL UNITS

Temp., Fahr.*	Cubic Centimeters of Condensate									
	1	2	3	4	5	6	7	8	9	10
35	2.52	5.04	7.56	10.08	12.60	15.12	17.64	20.16	22.68	25.20
40	2.51	5.02	7.53	10.04	12.55	15.06	17.57	20.08	22.59	25.10
45	2.50	5.00	7.50	10.00	12.50	15.00	17.50	20.00	22.50	25.00
50	2.49	4.98	7.47	9.96	12.45	14.94	17.43	19.92	22.41	24.90
55	2.48	4.96	7.44	9.92	12.40	14.88	17.36	19.84	22.32	24.80
60	2.47	4.94	7.41	9.88	12.35	14.82	17.29	19.76	22.23	24.70
65	2.46	4.92	7.38	9.84	12.30	14.76	17.22	19.68	22.14	24.60
70	2.45	4.90	7.35	9.80	12.25	14.70	17.15	19.60	22.05	24.50
75	2.44	4.88	7.32	9.76	12.20	14.64	17.08	19.52	21.96	24.40
80	2.43	4.86	7.29	9.72	12.15	14.58	17.01	19.44	21.87	24.30
85	2.42	4.84	7.26	9.68	12.10	14.52	16.94	19.36	21.78	24.20
90	2.41	4.82	7.23	9.64	12.05	14.46	16.87	19.28	21.69	24.10
95	2.40	4.80	7.20	9.60	12.00	14.40	16.80	19.20	21.60	24.00
100	2.39	4.78	7.17	9.56	11.95	14.34	16.73	19.12	21.51	23.90

*Temperature of the exhaust gases from the calorimeter.

*The formula for the heat given up in B.t.u. is

$$H = \frac{c\,(970.4 + 212 - t)}{454}$$

where
c = Cubic centimeters of condensate.
t = Temperature of the calorimeter exhaust gases, Fahrenheit degrees.

Oil Engines for Warship Propulsion

There is a probability of the British Admiralty ordering oil engines for a thorough practical test of their suitability for warship propulsion, says *Engineering* (London). Several torpedo-boat-building firms are to submit designs either for a destroyer to be propelled solely by internal-combustion engines or by oil engines in association with turbines supplied with steam from oil-fired boilers.

The designs are under consideration, and it is probable that of the 20 vessels of this class provided for under the navy estimates, two will have internal-combustion engines. One has been ordered in which it is intended to have a combination system of engines. This is the more convenient arrangement as the same oil is used as fuel in the boilers and in the internal-combustion engines, and makes possible the attainment of the normal cruising speed with these engines alone working.

With this arrangement the advantage of high economy will be attained at low speed and the radius of action of the destroyer at cruising speed will be nearly

doubled, exceeding 4000 miles. Oil fuel for the boilers and the turbines for driving the wing shafts will still provide for full speed when necessary, which can be had within a very short time from the steaming up of the boilers.

Although this is a limited application of the internal-combustion engine for warship propulsion, there is every probability that complete data will be obtained to establish the suitability of this prime mover for larger vessels and for greater powers.

Diesel Engines for Rome

The city of Rome, Italy, has contracted with Franco Tosi, of Legnano, for three 6-cylinder Diesel engines of 2000 brake horsepower each and two 3-cylinder engines of 1000 horsepower each for central-station service. These engines are of the vertical form and will operate on the two-stroke cycle at 136 revolutions per minute. They will be coupled to alternators which will deliver three-phase currents at 8200 volts. The guaranteed consumption of fuel oil of 18,000 B.t.u. heat value is as follows:

Load, percentage of rating	40	60	80	100	120
Fuel, pounds per brake hp.-hour	1.139	0.965	0.884	0.831	0.857

LETTERS

The Gas Turbine Problem

Mr. Blaisdell's suggestion of a two-fluid turbine, presented in the September 5 issue, is extremely interesting and ingenious but there are several drawbacks which he apparently overlooked. One serious mistake that he makes is the assumption that the gas and air will remain at the compression pressure when delivered into a combustion chamber which opens into the turbine without restriction. Another is the assumption that the combustion chamber will fill up with mixture at the compression pressure before any of the mixture ignites. Of course, I understand that the chamber is filled with steam at 200 pounds pressure before the explosive mixture enters and that this steam is expected to "back up" the inflow of gas and air and keep the pressure up, but that expectation may easily fail to be realized.

A third oversight by Mr. Blaisdell seems to be indicated by his assumption that enough steam can be generated at 200 pounds pressure by the waste heat in the exhaust gases. Assuming an explosion temperature of even 2500 degrees absolute and adiabatic expansion in the turbine, the gases could not leave the turbine at more than 1160 degrees absolute or 700 degrees above Fahrenheit zero. The temperature of saturated steam of 200 pounds gage pressure is 388 degrees and to make a pound of that steam from water of, say 176 degrees temperature (raised to that by jacket heat from the compressor) requires 1050 B.t.u. The gases cannot possibly drop more than

$$700 - 388 = 312 \text{ degrees}$$

in making the steam, so that in order to make one pound of steam 13½ pounds of exhaust gases would be necessary, assuming 100 per cent. efficiency for the boiler; at 84 per cent. efficiency the quantity would be 16 pounds. In other words, each pound of exhaust gases, and therefore of initial mixture, could make only one-sixteenth of a pound of steam of 200 pounds pressure under the most favorable possible conditions. This would not go far toward cooling the machine.

GEORGE W. MALCOLM.

New York.

I was very much interested in the article entitled "A Suggested Solution of the Gas Turbine Problem," by Benjamin H. Blaisdell, which appeared in the September 5 issue of POWER. It seems to me rather doubtful, however, that the combustion chamber would be mechanically able to withstand the flash-boiler effect due to intermittently introducing superheated steam. Still adhering to Mr. Blaisdell's plan of cooling by means of steam, I would suggest a mechanical change in the apparatus to permit the use of a steam turbine with the intermittent gas explosion superimposed. That is, have the steam continuously enter at an individual nozzle, retaining the feature of saturation regulation, and have the combustion chamber jacketed with the feed water and connected to a nozzle of its own, separate from the steam nozzle of the turbine. This arrangement would obviate any objections due to the flash-boiler effect, and it would increase the possible number of cycles per unit of time, because of the continuous steam flow and the resultant continuous cooling.

WALTER KNAPP.

Plainfield, N. J.

Performance of an Oil Engine Pumping Plant

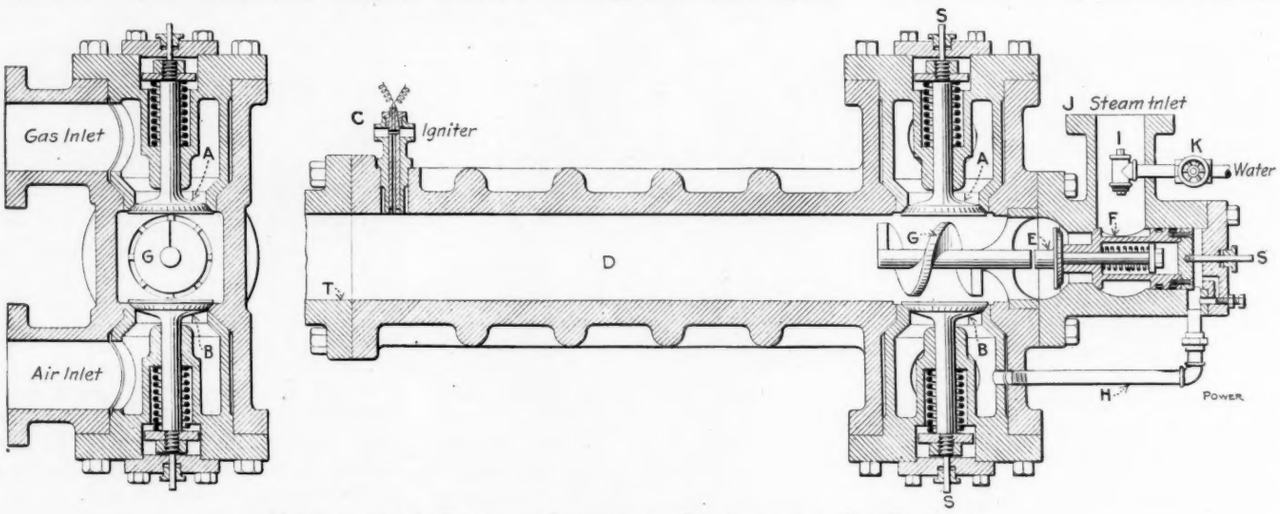
A new pumping unit recently installed at the Artichoke pumping station of the Newburyport waterworks consists of one 50-horsepower De la Vergne oil engine, type "H. A.," direct connected to a 12x12-inch triplex single-acting plunger pump. On a 9-hour test this outfit showed the following results:

Revolutions made by the pump shaft during test	22,147
Theoretical gallons of water pumped (17.625x22,147)	390,341
Allowance for slippage in pump	2%
Estimated gallons pumped	382,534
Estimated weight of water pumped, pounds	3,187,785
Total head against pump, feet	130
Estimated foot-pounds of work done	414,412,000
Total fuel consumed (34 degree distillate), gallons	36½
Foot-pounds of pumping duty per gallon of fuel	11,353,750

The builders guaranteed a duty of 10,400,000 foot-pounds per gallon of fuel, which was exceeded by a considerable amount, as shown by the above figures. When it is considered that the load factor was around 50 per cent., the results obtained are highly satisfactory.

L. C. TUCKER.

Newburyport, Mass.



MR. BLAISDELL'S PROPOSED COMBUSTION CHAMBER FOR A GAS TURBINE

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Keg Tank Float

Metal floats often cause trouble when used to indicate the water level in a tank, due to the cord sticking or to a leaky float. I have successfully used a small beer keg.

A flat bung is used to plug the bunghole. A hole is bored through the bung and the stave exactly opposite to the bung, and a piece of ⅜-inch brass tubing passed through them. The bottom hole must be a little smaller than the tube, so that the latter can be screwed in from the top hole. The threaded ends of the tube should extend ½ inch on either side of the keg. A socket hook is screwed on to the upper end of the tube, and a washer slipped over the tube on the other side of the keg, followed by a nut, which serves to tighten the rod to the keg. Such a float is good for years.

WILLIAM L. KEIL.

Philadelphia, Penn.

Double Eccentric Corliss Valve Setting

The object in having two eccentrics is to give the engine a longer range of cutoff which, in a single-eccentric engine, is limited by the exhaust valves as the eccentric must be set ahead of the crank about 115 or 120 degrees in order to give the proper compression and release. My method for setting the valves on a double-eccentric Corliss engine is as follows:

Place the wristplates in the center of travel. A mark will be found on the wristplate hub and another on the stud. If not, one can find the center of travel by dropping a plumb line so as to coincide with the center of the hook pin and the center of the stud. Be sure that the rocker arms are also plumb when the wristplates are hooked up and are at the center of their travel.

Now, adjust the valve rods until the proper amount of lead is had (which is 1/64 inch for an 8x24-inch engine and 3/64 inch for a 30x72-inch) and adjust the exhaust valves to the proper amount of lap (3/64 inch for the 8x24-inch and 3/16 inch for 30x72-inch). Then, with the crank on the head-end center move the steam eccentric ahead until the hook rod just hooks up to the wristplate, with the wristplate at the center of its travel. This will place the eccentric 90 degrees ahead of the crank minus the angularity of the connecting rod. With the steam wristplate hooked up, turn the engine over to the crank center and see if the same amount of steam lead is had; if not, make up one-half of it by moving the steam eccentric and the other half by changing the length of the connecting rod.

Next, move the engine over until the crosshead has reached a point about 1½ to 3¾ inches from the end of the stroke (according to the size of the engine) and, with the exhaust wristplate hooked up, move the exhaust eccentric ahead until the exhaust valve on that end is just closing. This will give about the right amount of compression. Next, move the engine over to within the same distance of the other end of its travel and observe if the other exhaust valve is just closing; if not, make up one-half of it with the exhaust connecting rod and the other half with the eccentric as was done with the steam valves. After putting the valve covers back in place the finer adjustments with the indicator can be made.

If another eccentric has been added to an engine which was built for one eccentric, it will be necessary to change the keyways in the steam-valve stems so that the steam arms will be on a level when the lead is had; if not, they will raise too high. This can be done with an offset key, but I prefer to turn the valve stems over and cut new keyways and fill up the old ones. The reason for changing the position of the keyways is that the lead is obtained with the wristplate in a different (earlier) position than that on a single-eccentric engine.

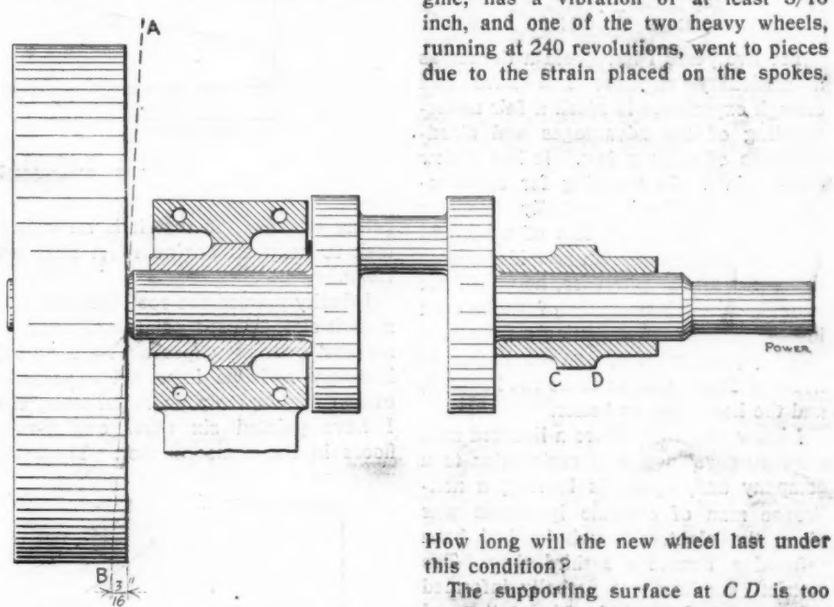
FRED R. HAWK.

Kansas City, Mo.

Poorly Designed Bearing

When an engine is designed with the bearings made as shown in the accompanying illustration, there will be a strain and a heating of the shaft, because the distance from the center of the bearings is too great from the center line of the crank rod.

The line *A B*, in the case of one engine, has a vibration of at least 3/16 inch, and one of the two heavy wheels, running at 240 revolutions, went to pieces due to the strain placed on the spokes.



FAULTY DESIGN OF BEARING

How long will the new wheel last under this condition?

The supporting surface at *C D* is too small and too far from the force applied to the crank's face, and the accident shows that this form of bearing is not the best suited for heavy loads; a bearing having a support close to the face of the crank is more desirable. Making the crank shaft larger does not remove the entire cause of vibration and the new wheel will eventually give way from the side springing motion as the slightest play on the surface at *A B* will cause trouble.

C. R. MCGAHEY.

Baltimore, Md.

Fixed Eccentric

The engine in question had an 8x16-inch cylinder and evidently the maker did not contemplate any change in the valve setting as the eccentric was cast solid with the hub of the crank.

Shortly before I made its acquaintance a new valve had been made for it and it required constant attention to keep up steam. On examination it was found that on one end of the cylinder the steam followed the piston 15 inches and on the other stroke 15½ inches. As the eccentric could not be changed, measurements were taken and a pattern made for casting a new one. The old eccentric and crank were removed and the eccentric turned down to form a hub on which to mount the new one.

After fitting the new eccentric and strap in place and setting the valve to cut off steam at 7 inches of the stroke, the eccentric and hub were marked for keyways. When the engine was started up it ran smoothly and it only required about one-half as much fuel as before to keep up steam. In this case it was the late release, no compression and late port opening that caused the trouble; it was remedied by advancing the eccentric.

J. C. HAWKINS.

Hyattsville, Md.

Condemns License Laws

For five years I have held a license as a stationary engineer and have had enough experience to reach a fair understanding of the advantages and disadvantages of such a law. It has a few good points. In studying for examination, the applicant naturally becomes more interested in his line of work and becomes acquainted with new ideas, laws and rules which, otherwise, he would not have known. But many of these men lose all interest after getting a license.

As for wages, they are no higher in licensed States than in those not licensed, and the hours are no better.

I know of a case where a licensed man gave 10 days' notice of resignation to a company and, upon his leaving, a non-license man of extreme ignorance was given the plant, although he had been refused a license the third time. The district examiner was verbally informed and was asked to take up the matter and see that a licensed man operated the plant, but he was allowed to run over a month and the company took its time in putting in a permanent man.

Violations of this law are very common, but there are but few prosecutions for its violation. If there were more prosecutions the law would meet with more favor.

Engineers must take the examination and pay their $2 whether they pass or not, and in some States and cities they pay $2 for the renewal of the license. They are held liable for violations and run the risk of losing their jobs; what benefit do they receive from the law?

One contributor recently asked how some of the kickers against license laws would like to see laborers taken out of a trench and put in charge of steam boilers as has been done in no-license States.

I know of men holding licenses who worked in a trench and ought to be there now. A capable man, having charge of nearly 1000 men in a license State, in discussing licensed engineers, said that he could take any one of these men and get them a license inside of 30 days. Judging from some of the engineers he had they must have been 30-day men.

RAY GILBERT.

Virginville, W. Va.

Painting Engine-room Floors

Various methods are in vogue for the treatment of concrete floors of engine rooms, and I have tried most of them with various degrees of success.

A concrete floor is in itself very porous and readily absorbs grease, dirt, lubricating oils, etc., so that it is an endless task to keep an engine room neat and clean.

I finally painted the concrete floor with a dark slate-colored paint, and after six months' wear the experiment was so satisfactory and the improved appearance of the engine room so remarkable, that I have painted six other engine-room floors in the same manner. There are several manufacturers who furnish concrete-floor paint and will send color cards and samples to those interested.

Before applying the paint the concrete floor should be thoroughly cleaned and scrubbed by the use of a live-steam hose, caustic-soda or an acid solution. The floor should have time to dry before applying the paint with a brush; then be sure that it is well worked into the concrete.

The first coat should be allowed to dry for 48 hours and be hard before applying the second coat. The paint renders the concrete floor impervious to water or oil, as it closes the pores; it also prevents concrete dust which is a nuisance in an engine room.

I have also put into each engine room a strip of woven-wire matting as it increases the life of the painted floor.

In cleaning the painted floor, waste and soft rags can be used to wipe up; never use caustic soda or hot water.

A. RAUCH.

Swissvale, Penn.

Compression Unnecessary

The diagrams shown herewith were taken from a cross-compound Corliss engine with cylinder diameters of 22 and 40 inches, stroke 36 inches. The ammonia cylinders were driven tandem with each steam cylinder. The engineer of the plant would like to have the readers of POWER suggest any changes that might be made in the valve setting to give better results.

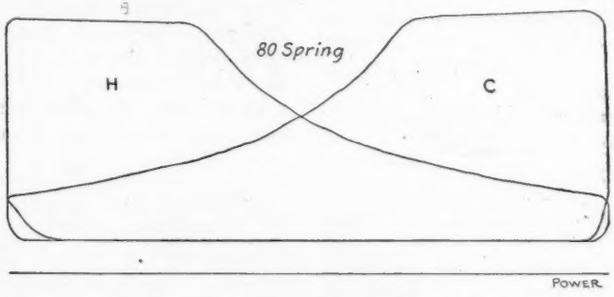


FIG. 1. HIGH-PRESSURE DIAGRAM

S. KIRLIN.

Mobile, Ala.

[When ammonia compressors are arranged in tandem with the steam cylinder of an engine no compression is required in the steam cylinder, as the compressor will furnish all that is necessary. —EDITOR.]

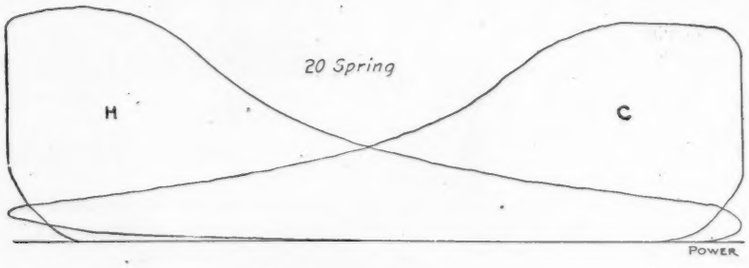
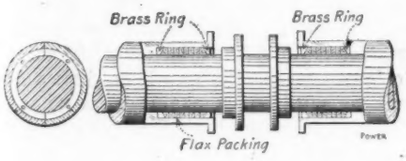


FIG. 2. LOW-PRESSURE DIAGRAM

Piston Rod Packing

I recently had occasion to remove the plungers from a duplex vertical compound boiler-feed pump and true up the rods on a lathe because ridges had been worn in them by sand, etc. A cut of about 0.026 inch was taken off, and when the pump was assembled and tried out it leaked badly at the stuffing boxes. This was due partly to the water coming from a heater at a temperature of about 180 degrees which affected the packing, and partly because of the cut taken from the



HOW THE ROD WAS PACKED

plunger rod which left the stuffing box a little loose.

The stuffing boxes were adapted to metallic packing, which was put in when the pump was assembled. Nearly every kind of packing was tried, but it was ineffective. A cylindrical piece of brass 8 inches long was used which was large enough in diameter to fit the stuffing boxes of the pump when the brass was turned down.

Four rings were made, each about ⅝ inch thick outside, ¼ inch inside, ¾ inch wide and about 9 inches in diameter. Each ring was beveled from the outside toward the center. Four bolt holes were then scribed on the face of each ring and drilled and tapped for ¼-inch bolts, thus making it easy to lift them from the stuffing boxes by screwing two ¼-inch bolts in each ring. These rings were sawed in half because the pump was so designed that it would have been necessary to take it apart in order to put them in whole.

Some ¾-inch flax packing coated with graphite was at hand, and after placing one of the brass rings in the bottom of the stuffing box with the beveled side toward the gland, we put in these rings of flax packing, leaving room for the other brass ring; the rings were placed in the opposite position to the first and having the flat side next to the gland, as shown in the illustration. The same treatment was given to the other three stuffing boxes. The gland was tightened, thus forcing the packing toward the plungers.

With an occasional forcing in the gland, the stuffing boxes have held tight for 10 months.

If trouble is had with sand in the pumps, I advise the use of a ring of woven copper packing in the bottom of the stuffing box before placing the first brass ring.

WALTER A. COX.

West Orange, N. J.

Jacobs-Shupert Locomotive Firebox

The Jacobs-Shupert locomotive-boiler firebox possesses the novel and commendable feature of being constructed without staybolts. At least, my impression is that it is so built.

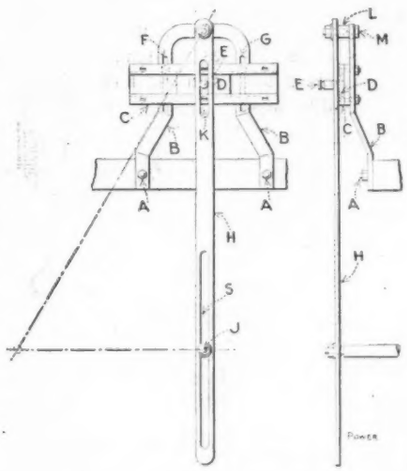
Why could not this type be adapted to stationary boilers to good advantage?

LLOYD V. BEETS.

Nashville, Tenn.

Homemade Indicator Reducing Motion

The accompanying sketch illustrates a homemade indicator reducing motion. It is a neat arrangement and accurately transmits the crosshead motion, as it has not the error due to the use of an arc.



INDICATOR REDUCING MOTION

This device is attached by two studs *A* to the guide barrel of the engine, and is placed as near as possible to the center of motion of the crosshead. The support *B* is made of 1x¼-inch flat steel, forged to the required shape and then polished. The pieces *C* and *D* constitute a slide and its guide. They are made of brass and polished. The pin *E* is screwed into the slide *D* and has a groove to which is attached the cord leading to the indicator, and the frame *B* is slotted at *F* and *G* so that *C* can be raised or lowered, thus shortening or lengthening the stroke of *E*, according to the stroke of the engine.

The arm *H* is made of flat steel and is polished. The slots at *S* and *K* must be carefully made so that there will be no looseness in the pins *E* and *J*.

The two nuts at *L* and *M* clamp the top pin to the frame, and the outside nut prevents the arm *H* from working off, but it must be loose enough to allow the arm *H* to swing freely. Pin *J* is attached rigidly to the crosshead, usually by screwing it into a hole made for that purpose. As the crosshead moves forward and backward the arm *H* transmits the motion to the pin *E*, and to the indicator by the cord.

The device may seem more complicated than is necessary with no decided advantages, but with all the parts polished it makes a very attractive addition to the engine. When not using the indicator the arm *H* can be easily disconnected. There is no figuring for any special size as the device will fit any engine by adjusting *C*.

EARL LYON.

Oakland, Cal.

Keyed Piston Gave Trouble

While working as an operating engineer some years ago I had an experience with a tandem-compound engine which I will long remember.

The pistons were made with a taper fit on the rods and were held in place by keys.

A pound, which only came once in a while, would sometimes disappear for a week at a time, but when it did come the whole engine would shake.

BENT KEY

After trying all kinds of adjustments on the pillow block and connections I still got the same pound at times, although the indicator cards showed good valve adjustment.

Then I decided that the pound was in the low-pressure cylinder. I backed the piston rod out of the crosshead, and started to drive the key out of the low-pressure piston, when I found that the piston was upside down on the rod.

The only thing to do was to swedge the key out a little and drive it back in again. I then tried the key on the high-pressure piston and found it offset as shown in the accompanying illustration.

The high-pressure piston had been pounding by being driven up on to the taper of the key. I chipped out the keyway so as to allow the key to draw up the piston on the rod and made a new key. The engine was then put together and gave no more trouble.

S. H. WINTON.

Woonsocket, R. I.

A locomotive of 1000 horsepower driven by a Diesel engine has just been set to work on the Prussian State Railways. The drive is direct to the axles, and the outward appearance is similar to that of an electric locomotive. Nearly $60,000 have been spent in experimenting with this engine.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Central Station versus Isolated Plant

Not realizing at the time I wrote the article published in the July 11 issue that so much interest would be shown in my case, I did not make myself as clear as I might have, so I will use John Bailey's questions in POWER for August 29 to clear up my former statements.

I am not in possession of the central-station prices; besides, the power will be used in all three buildings, *X*, *Y* and *Z*, shown in Fig. 1 herewith, whereas but two were supplied by the steam plant.

There are no other plants in the vicinity. The shop was located on the present site in 1790 to get the use of the water right.

The central station already has poles by and beyond the shop for town street lights and only had to extend its high-tension lines three miles to connect up.

Building *X* is the only one heated by steam and 2 pounds pressure is sufficient.

The plant is already motor driven. All that was necessary was to step the high-tension current down to 550 volts and install a double-throw switch in place of a single-throw, current in both cases being three-phase, so that feature was easily taken care of.

The high cost of coal is due largely to transportation and to transmission losses

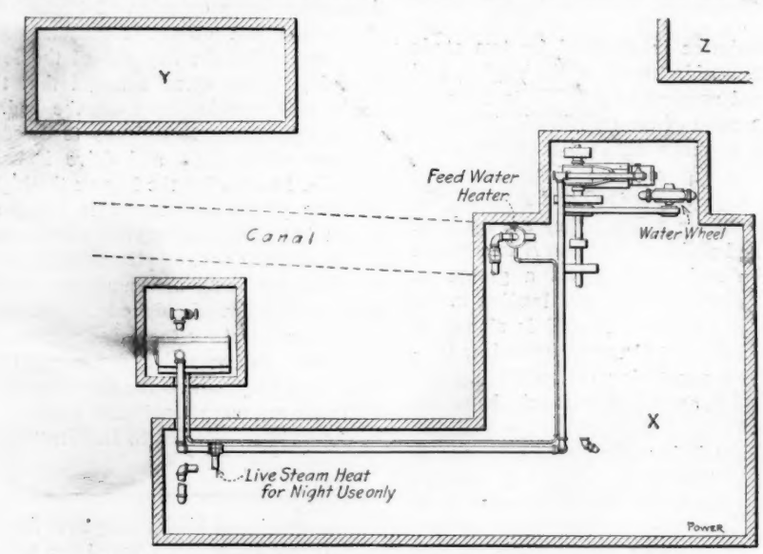


FIG. 1. ARRANGEMENT OF BUILDINGS

of the steam. The straight pipe is covered; the elbows are not. The necessity for 148 feet of pipe and 7 ells lies in the fact that the engine was placed so that it and the waterwheel might operate the same jack shaft. As to the 25-pound drop, the pipe is 5 inches to the last ell, which is a reducing ell 5x4 inches. Also,

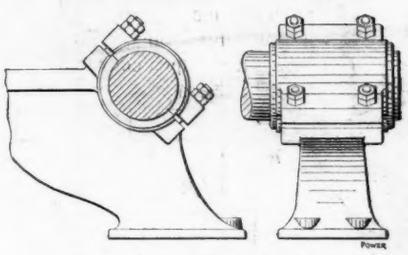


FIG. 2. MAIN BEARING DESIGN

there is present a large amount of condensation with no separator to take care of it.

The feed-water heater is a Patterson-Berryman, but as the feed pipes practically follow the line of the main steam line and are bare the gain is not much. The gages are correct, according to the Hartford Steam Boiler Inspection and Insurance Company standard.

Now I am aware that on the face of the matter there is chance for criticism, so I wish to state some of the various improvements I recommended. One was to cover the ells on the main line, and to cover the feed-water line. Then I tried to induce the manager to let me use buckwheat and install proper furnaces to burn it economically. Then there was talk of putting the engine close to the boiler, discontinuing the waterwheel (there is not water enough for it 10 months in the year) and running condensing. Another suggestion was to compound the engine as there are 20 pounds at the point of release.

The key to the situation is just this: the former management, which lasted for 17 years and ended a year ago, was of the old school and could not appreciate the importance of present-day practice; also, the business was run nearly into the ground. When the new man took hold there was so much to be done in the way of repairs, remodeling and reviving the business and so much expense to put the power plant on an economical basis that everything could not be done. The production end had to be considered first for without that no power would be needed, so my department had to be the one dropped. Another item of expense would have been the rebabbitting of the main bearings of which Fig. 2 shows

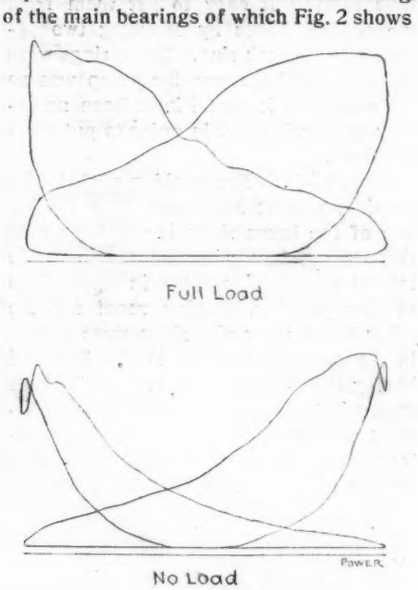


FIG. 3. INDICATOR DIAGRAMS

the design. They are just simple bearings with no takeup other than liners, and so badly worn on the side toward the cylinder that the piston and valve ends were taken

up to the limit in order to keep the clearance and valve setting right. As will be seen from the indicator diagrams in Fig. 3, there is still an inequality.

All in all, the central station has had a very good chance, and for myself I cannot blame anyone. I must say that had the general manager and myself exchanged places, I should have done as he did, I think.

EMMET BALDWIN.

Sturbridge, Mass.

To Prevent Standpipe Freezing

In response to Mr. Nicholson's inquiry in the September 12 issue I suggest the following arrangement to prevent a standpipe from freezing:

Use an ejector, size about 1 inch; the suction side of the ejector to be connected with the standpipe, the discharge side of the ejector also to be connected to the standpipe. Both connections should be made close to the bottom, the holes for the two connections being about 3 feet apart. Then, when the steam connection is made to the boiler and the steam is turned on, the warm water will circulate through the ejector, thus warming the water in the standpipe and causing a circulation.

The office of the ejector is to quiet the noise of the steam when coming in contact with the cold water, which noise would be objectionable if the steam were turned directly into the standpipe. It is understood that the discharge must enter at the lowest point of the standpipe as all water below this point would be likely to freeze, and the warm water would never go downward except by force. If the bottom of the standpipe is not accessible, then the discharge from the ejector must be projected inside and downward to the bottom and there turned horizontally.

D. M. SULLIVAN.

Camden, N. J.

Potblyn, Pump Doctor

Referring to Mr. Watson's excellent story in the issue of September 19 under the above caption, I have had many troubles such as he describes. In one instance we were using live high-pressure steam for glue kettles and drying apparatus. The returns from these passed through traps to a receiver tank and when the pump was not steam bound the gravity low-pressure heating system would be air bound. There was a vent pipe with a stop valve on it connected to the top of the tank. With this valve closed and the gravity returns shut off, unless some of the traps were discharging, there would be a vacuum in the tank. The suction pipe of the pump was connected at the bottom of the tank and rose about 2 feet to the pump. With the tank half full of water at 212 degrees, giving off vapor, the pump became steam bound. Cooling it with water worked well if the water in the tank was cooled and a proper amount of air admitted or a small steam pressure put upon it to break the vacuum in the tank. A small valve closed by a small spring and opening inward admitted air and prevented a vacuum forming.

The vent valve opened whenever the low-pressure return pipe became air bound, and cold water was admitted to the suction pipe when the pump became steam bound. Either of these troubles would cause the pump to run fast or run with a jerking stroke and pound.

I tried to get a trap to put on the heating system. This would permit taking the pressure off the tank by leaving the vent open. But the management could not see the benefit to be derived.

In a plant where there was an indirect heating system and where live and exhaust steam were used for various purposes traps were employed, which discharged into a return tank. This tank had all of the return pipes connected into or near the top, and a gooseneck water seal at one end. With the tank full of water, when the engine stopped the two heater coils would immediately be filled with water. These coils, consisting of four radiators each, discharged through one large trap. This was the first case I had experienced of a vacuum in the coils drawing the water back through the trap. With the tank only half full, the water being below the discharge pipe from the trap, only air would pass through the trap to the coils.

There are some traps, such as those with valves of the piston type, which would prevent this trouble.

The feed pump would occasionally get steam bound due to the returns being too hot.

The closed heater had a 1-inch drip pipe without a stop valve in it, draining the heater of condensation which carried with it much cylinder oil that would otherwise go up into the heating system.

When I took charge of this plant I remarked the waste of steam through this pipe as if it had no stop valve on it. What I could not understand was why this pipe did not supply the coils with air enough to destroy the vacuum forming in it. I was told that the pipe was to be left open to insure the drainage of the oil from the heater. On my search to find out why the air did not go back through the pipe, down in a corner under a pile of old grate bars and other junk I found a ¾-inch check valve, the pipe having been reduced to this size, and the drip from above the throttle connected to the 1¼-inch outlet, beyond. This told the story. The check valve closed against the inrush of air and consequently the air had to pass through the return tank to the manifold coils.

In another instance, I was called by my fireman to attend to a pump which seemed to run well but would not feed the boilers. The pump rested on a foundation about 18 inches above the floor while the tank was below the floor. Most of the return pipes entered at the bottom of the tank. The 4-inch suction pipe passed down to within 6 inches of the bottom. There was no pounding to mention, but the pump did not discharge any water.

After studying a while I concluded that the pump was air bound, although the tank was full of water. So, closing the discharge valve and opening the drip from the discharge chamber, I ran the pump slowly and the air was soon expelled. The fireman admitted later that the tank had been pumped dry. The air in the suction pipe had filled the pump cylinders and the pistons would simply compress it against the discharge valves without opening them.

What I would like to know is this, why will an air pump work with a vacuum in the suction pipe while a boiler-feed pump will not take water from a heater in which there is a vacuum?

R. A. CULTRA.

Cambridge, Mass.

Massachusetts License Laws and Examiners

The letter of J. A. Levy in the August 1 number has opened a discussion of much interest to engineers in this State. Most of the letters in answer to his have made no defense of the present license law or method of examination other than to belittle him, thereby drawing attention from the real issue, which is the method of examination.

That I may escape being called "sorehead" and other undesirable names, I wish to say that I have held a first-class license for ten years. Perhaps I should join with certain other engineers who have "got by" and denounce everyone who makes a protest against present conditions; anyone can easily see that if the number of first-class licenses is limited those who have "got by" will benefit.

I believe the Massachusetts license law, especially after the recent amendments go into effect, is the best I have heard of; but that is no reason why it should not be criticized. Engineers' license laws are supposed to be for the protection of the public—not to raise the wages of the engineers or to provide jobs for inspectors; therefore the examination should be to determine if the applicant is capable of operating a steam plant safely, and when an inspector goes further he oversteps his authority. The law expressly says: "The applicant shall be given a practical examination," etc.

It seems to me that the trouble with the examination is in the interpretation of

the word practical. The dictionary defines the word thus: "pertaining to practice, action or use; not merely theoretical; that reduces knowledge or theories to actual use; derived from practice or experience; skilled in actual work." How can certain examiners square their questions with that definition?

If every first- or second-class engineer is required to design a boiler, why do we have need of a board of boiler rules in this State to lay down rules as to how every boiler shall be built (the boilermakers having to conform to these rules); it would seem that the engineers' examination should cover the care and operation of boilers and not their design.

I am a member of an organization of engineers that has a membership of over 200, and there have been questions discussed at the meetings that have been asked applicants for second- and third-class licenses that could not be answered by first-class engineers. These engineers are advised by one writer to "take down their dust-covered books and magazines and get busy and that 'something wrong' spoken of by Mr. Levy would disappear."

The most of us are too busy studying how to keep down the cost of power as the price of coal mounts higher to waste time with a question asked by some examiner which has no bearing on the safe operation of a steam plant. I do not wish to be understood as criticizing all inspectors or examiners.

There is one here in the west end of the State of whom I have never heard a complaint; he has held his job for many years; everyone speaks well of him; but every applicant he examines is satisfied when he comes out of his office that the examiner has found out all he knows about engineering and that he has not been attending a pink tea. This examiner uses tact, judgment and patience, gives the applicant a practical examination and does not bulldoze him.

The inspectors say they have orders to stiffen up on the examination. Where did these orders originate? We are sure the legislature has not ordered a more thorough examination, so the order must come from somewhere within the boiler-inspection department. Why should the department wish to make the examination harder? Have accidents been caused which could have been prevented by a stiffer examination of someone? I think not. Many stories are in circulation as to why the examinations are harder than formerly; some think certain engineers holding first-class licenses have brought pressure to bear on the boiler-inspection department in some way, that they may limit the number of first-class engineers. That hardly seems possible, yet we remember a few years ago there was quite a stir about the special-license clause in the law. An amendment was presented to the legislature and adopted, limiting the issue of special licenses to have charge of plants to those not exceeding 150 horsepower (the second-class limit).

It does seem peculiar that the special license should apply only to second-class plants and below. If I held a second- or third-class license, I should feel that someone was "putting it over," especially, since the legislature has been in session four times without any attempt at relief for the second- and third-class men. I have heard chief engineers say they preferred men with special licenses. One said lately that he would fill the next vacancy with a special-license man, and gave as his reasons that a special-license man would stay with him, but a man with a regular license was always looking to better himself and might leave him. It seems strange that steam plants up to 150 horsepower are safe in charge of special-license men while those above that size are not. There are those who say that the trade schools and those having books for sale have something to say about examinations. People who thus criticize the method of examination may be "soreheads," but it is a fact that their number is growing rapidly. If the examination is made harder, to protect the public from men operating dangerous machinery who are not competent, why do the examiners grant men special licenses (with practically no examination), to have charge of a steam plant who they claim are not competent to carry a classified license covering the plant?

If special licenses must be issued, they should be limited—that is, the holder of a special should be required (say in six months) to pass the examination for a regular classified license covering the plant. At the present time, if an accident happens, the boiler-inspection department steps in, and if the engineer is found negligent his license is revoked. This is as it should be, but it is far more necessary to prevent accidents than to punish someone for negligence afterward. Every steam plant should be visited at least once each year by an inspector whose duty it is to see that all boilers, engines, piping, etc., are in a safe operating condition; the owner would then learn that because a man holds a first-class license it is no proof that his plant is in a safe condition.

Visit some of the large electric-light or street-car power stations about 6 p.m., when the peak load is on, and you will find many engines running with the pin in the governor column which means a runaway engine if the governor belt breaks or slips off. Look at the boilers and piping, many of them are running on the "ragged edge" till a more favorable time for repairs. Never mind the danger to life or serious injury, the wheels must be kept turning. I mention these types of plant particularly as they are always in charge of men carrying first-class licenses.

I wish to call attention to the need of at least annual inspections of all steam plants by competent men. Mr. Levy says he "hopes to see this vitally important matter liberally discussed in the columns of POWER." I fear he will not hear from many of the second- and third-class engineers, the men who are most interested in the subject; they are afraid to criticize existing conditions because they will be "spotted" by the examiners.

I have talked with a number in this section and they agree with Mr. Levy, but they fear to come out openly. I believe in license laws, in the Massachusetts law if we can get no better; I believe the second- and third-class license holders are not getting a square deal, and that the examinations given by certain examiners are not practical.

C. C. HARRIS.

Springfield, Mass.

After reading the various criticisms in the September 5 issue on Mr. Levy's letter in a previous issue under the above title, I am moved to take up the cudgel in his behalf for I think he has been brought to task a bit unjustly. I am quite familiar with the particular case of which he wrote. In fact, I had the opportunity of giving the applicant in the case a preliminary examination, at his request. It seemed certain to me that he would pass the examiners' ordeal with flying colors.

I believe it is the duty of the examiners to ascertain how much an applicant knows about engineering rather than to try to confuse and disconcert him. The law has always explicitly stated that an applicant should be given a practical examination.

S. F. PUSTUN.

Springfield, Mass.

Status of the Engineer

I have read with much interest the editorials and articles which from time to time have been published in POWER on this subject, and I have long ago come to the conclusion that if an engineer permits his employers, or supervisors to treat him with just about as much, if not less, respect than is given to the ordinary laborer, it is more or less his own fault; in my opinion, an engineer who does not uphold the dignity of his position at all costs degrades the whole profession in a greater or lesser degree.

With this in view, I would like to relate an experience I had a couple of years ago with an employer who thought his engineer should be his loblolliboy and to whom he gave less respect than to the commonest laborer about the plant. It was an ice-making and cold-storage plant of about 120 tons capacity per day, run on the ammonia-compression system; a 35-ton Linde machine had been installed by the then chief engineer who had with

his own men put in the concrete foundations, assembled and erected the engine, compressor, condenser, etc., and started the machine without any outside help. This was done in addition to his other duties, for the other portion of the plant was running continuously. The manager, who was also a shareholder and director of the company and posed as an amateur engineer, although he had been a captain on a Nova Scotian brig, thought he had reason to be dissatisfied with the performance of the new machine, as well as the work of his engineer. Consequently, he wrote back East asking the makers to send him a first-class engineer, as he could get nothing but "shovels" on the Pacific coast.

As luck would have it, I was asked if I would go out to the Pacific coast to take charge of this plant. I demurred for a considerable time, as I then had a good, comfortable position as engineer in one of the largest bank buildings in the East; however, after a correspondence extending over some four months, I came out here to the coast, with the promise of my transportation being paid and $150 per month salary.

Immediately upon my arrival I reported to the manager, whose character became apparent before I had had 15 minutes' conversation with him, and I knew there was trouble coming. As I had to get my license, he took me over to a neighboring town and introduced me to the boiler inspector, who gave me a special three days' examination for a first-class certificate, which I secured.

Before I had had charge of the plant a month the manager and I were at loggerheads, as he had the habit of wandering about the engine room, and altering the ammonia-expansion valves on the headers to the coils in the brine tanks, and to the different rooms for fish freezing, meat storage, egg and butter rooms, etc.

At last I could stand it no longer, and I ordered him out of the engine room, quietly informing him that the plant was run on my certificate, and that I was the responsible engineer. After this, he got very friendly with my assistant, who kept the night watch from 7 p.m. to 7 a.m. He pursued the same tactics after I had gone for the night, with the result that on one occasion when I came down in the morning, I found that not one pound of ice had been made in the 12 hours, and the temperature of the brine was standing at 28 degrees Fahrenheit.

I immediately charged my assistant with collusion with the manager, with whom, when he put in an appearance I had a battle royal, for I had found all the expansion valves had been altered again. The manager demanded my resignation, which I refused; he then said he would be obliged to discharge me that evening, to which I submitted, merely remarking that he might prepare himself for the consequences.

The next day I put the matter into the hands of an attorney, and commenced a suit for a month's salary in lieu of notice of dismissal, etc.

The manager denied owing me anything and further wrote he had to discharge me for incompetency. I immediately entered action for $1000 damages. The case was tried in the superior court and took four days, as the manager brought 19 witnesses, all, of course, in his employ, while I was alone and 3000 miles away from friends. However, I won my case on every point, and got my salary, damages, transportation, etc., the other side having to pay all court costs.

Now for the sequel. My former assistant was appointed chief; and before he had the position three weeks he burnt both boilers and brought down the furnace crowns through letting oil get into the boilers. This happened in the very hight of the summer season when the demand for ice and cold storage is greatest. The whole plant was shut down for six weeks to make repairs to the boilers. To keep their trade, ice had to be bought at another factory 30 miles away and shipped in for distribution; several thousand dollars worth of beef, mutton and produce were also spoiled through not being able to keep the temperature of the cold rooms down. Altogether, it cost the company some $12,000 because their manager and director thought he knew it all.

It does not always pay to interfere with a properly qualified and competent engineer when he is attending to his duties in a proper manner.

JOHN CREEN.

Seattle, Wash.

Indicator Diagrams

Some time ago there was an article in POWER dealing with indicator diagrams. Among others was shown a valve-gear diagram, or one made with the drum motion taken from the eccentric rod.

I submit the accompanying diagrams taken from a 16x36-inch Fitchburg engine having a cam-motion valve gear and running 100 revolutions per minute.

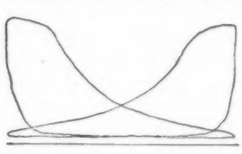


FIG. 1. DIAGRAMS TAKEN IN USUAL MANNER

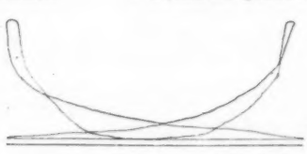


FIG. 2. DIAGRAMS TAKEN WITH DRUM MOTION RECEIVED FROM CAM ROD

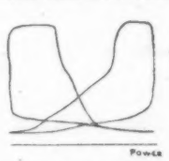


FIG. 3. DRUM MOTION TAKEN FROM EXHAUST ECCENTRIC ROD

The diagrams in Fig. 1 were taken in the usual way. Those in Fig. 2 were obtained with the drum motion taken from the rod which connects the lower ends of the cam levers. The diagrams in Fig. 3 were taken with the drum motion from the exhaust eccentric rod.

All of the diagrams were taken with a 60 spring and with the same reducing motion, but as the travel was not the same at the different points where the string was attached the lengths of the diagrams differed as might naturally be expected.

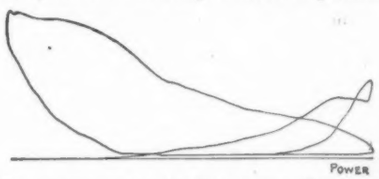
Notice that the compression curve and the point of admission show very plainly on the diagrams in Figs. 2 and 3.

L. A. FITTS.

West Fitchburg, Mass.

Testimonial Letters

In a recent issue there were two testimonial letters regarding a well known and reliable make of indicator. They were written by a Mr. Cole who "upon applying the instrument" found he "was pulling almost one-fifth more load from one end of the engine than from the other, which naturally caused a pound."



DIAGRAMS FROM UNBALANCED ENGINES

(Incidentally, it may be stated that about a month after indicating the pound Mr. Cole was advanced from engineer to manager of the plant.)

It would be quite interesting to see the "before" and "after" diagrams, accompanied by a description of what lost motion was taken up before the pound was eliminated.

Several times I have secured diagrams from engines which were unbalanced to such an extent that the lights showed plainly the uneven action, but there was no pound when the bearings were all in good condition.

The accompanying diagrams were taken from a generator engine supposed to run at 250 revolutions per minute, and, although the indicator proves the engine to have been in an almost single-acting condition, yet there was no sign of a knock.

If Mr. Cole is still a reader of POWER I would be pleased to have him estimate the pound that ought to synchronize with the accompanying diagrams.

By all means, keep the engine balanced but do not overlook the rod brasses, etc.

J. A. CARRUTHERS.

Hosmer, B. C.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Relation of Belt Speed to Pulley Diameter

Does the diameter of a pulley control the speed at which the belt travels?

W. A. W.

At a given belt speed the revolutions of either driving or driven pulleys are proportional to the pulley diameter. The diameter of either pulley multiplied by 3.1416 and by the revolutions per minute of that pulley will give the belt speed.

Belt for Given Horsepower

A 4-inch single belt transmits 14 horsepower, the driving and driven pulleys being of equal diameter and revolving at 400 revolutions per minute, neglecting slip. Find the size of these pulleys.

A. D. B.

Any one of a number of rules may be used for this problem, depending upon the working tension allowed per inch of width. Selecting formula 4, page 877, "Kent," in which the working tension is taken as 45 pounds per inch of width, for single belts,

$$Horsepower = \frac{wv}{733}$$

where

w = Width of belt in inches;

v = Velocity of belt in feet per minute, which is equivalent to $\frac{\pi \times d \times r.p.m.}{12}$

in which d is the diameter of the pulley, in inches, and $r.p.m.$ represents the revolutions per minute.

The formula may be expressed as,

$$Horsepower = \frac{w \times \pi \times d \times r.p.m.}{733 \times 12}$$

Substituting the known values,

$$\frac{4 \times 3.1416 \times d \times 400}{733 \times 12} = 14$$

$$d = \frac{733 \times 12 \times 14}{4 \times 400 \times 3.1416} = 24.5 \text{ inches}$$

A 24-inch pulley would suit the purpose.

Size of Corliss Engine Governor

How could one tell by simply looking at it if the governor on a Corliss engine was large enough for the work? This question was asked me at a recent examination.

E. H. H.

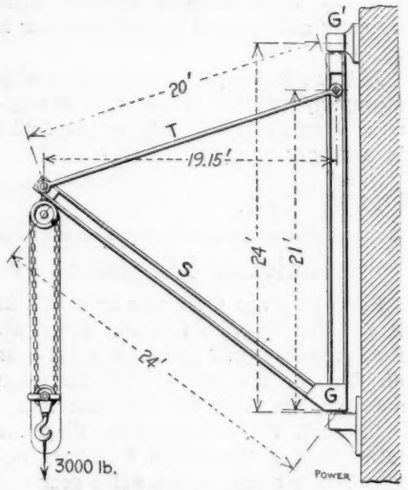
The question is intended to test the familiarity of the applicant with the functions of the Corliss-engine governor. It has practically no work to do. It simply adjusts the cutoff. Any governor which a builder of Corliss engines would put on would be large enough.

Stress in Crane Members

If a load of 3000 pounds is supported by a crane of the dimensions given in the figure, what is the stress in the strut S, in the rod T and the horizontal pressure against the top support of the mast?

P. J. F.

The compression in the strut is computed by multiplying the load in pounds



SKETCH OF CRANE

by the length of the strut in feet, divided by the horizontal distance from the base of the strut to the point of attachment of the tie rod.

$$3000 \times \frac{24}{21} = 3428 \text{ pounds}$$

compression in S.

The tension in the tie rod is found by multiplying the weight in pounds by the length of the tie rod in feet divided by the horizontal distance between the point of attachment of the tie rod to the mast and the base of the strut.

$$3000 \times \frac{20}{21} = 2857 \text{ pounds}$$

tension in T.

The horizontal distance from the load to the mast is 19.15 feet. The moments about the point of support G must balance.

$$3000 \times 19.15 = G' \times 24$$

$$G' = \frac{3000 \times 19.15}{24} = 2400 \text{ pounds}$$

horizontal pressure at G'.

Diameter of Staybolts

The pitch of the staybolts in a boiler is 6 inches each way and the pressure carried is 100 pounds per square inch. What diameter of staybolts will be required if the stress allowed in the bolts is 6000 pounds per square inch?

F. L. H.

If the pitch of the bolts is 6 inches, each bolt will support 36 square inches and at 100 pounds pressure per square inch the total pressure supported by each bolt will be 3600 pounds. If a stress of 6000 pounds per square inch is allowed upon each the area will be

$$\frac{6000}{3600} = 1.666 \text{ square inches}$$

at the bottom of the thread. The nearest commercial size will be 1⅝ inches diameter.

Advantages of Butt and Strap Joint

What are some of the advantages of a butt and strap joint over a lap seam?

C. A. S.

The lap seam will not permit truly cylindrical construction and hence a bending action or flexure occurs along the seam which frequently results in an explosion. The butt joint, double strapped, allows truly cylindrical construction of the shell and no flexure takes place with pressure changes. The longitudinal seam is the weakest part of a boiler. Double-riveted lap seams usually are 70 per cent. as strong as the solid plate, while butt joints are from 85 to 94 per cent. as strong as the whole plate.

The electrification commission of the Chicago Association of Commerce, which is just beginning a comprehensive investigation of the municipal problem indicated by its title, has determined, as one of its first deliberative acts, to adopt the Ringelman chart system as a basis of comparison to determine the density of smoke. The next "act" will be the choosing of competent inspectors.

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POWER

Receiver Pressure

Receiver pressure is probably as often discussed as any other question connected with steam-engine operation. It is claimed by many engineers that the load should be equally divided between the cylinders of compound engines, and that the receiver pressure which equalizes this distribution is the best. It is the cutoff on the low-pressure cylinder which determines the distribution of the load between the cylinders, the receiver pressure, and to the extent to which it influences the efficiency of the engine the cutoff on the high-pressure cylinder. It is the cutoff on the high-pressure cylinder which determines the quantity of steam used by the engine. This point is indicated approximately by the hight at which the governor revolves. But the clearance, degree of compression and the receiver pressure modify the quantity of steam admitted to the cylinder at each stroke. Either compression or the receiver will fill the clearance space with steam at the corresponding pressure.

Without either clearance or compression the volume of steam admitted to the cylinder up to the point of cutoff will be the piston displacement up to this point. With clearance, if the receiver pressure could be made equal to the initial, no steam whatever would enter the cylinder until after the piston had begun to move forward and thereby lowered the pressure in the cylinder, and the volume admitted would equal the piston displacement.

Engines are not built without clearance and in addition to the piston displacement the clearance space must be filled with steam at initial pressure and it is here that compression may modify the volume required from the boiler. If the compression is carried to initial pressure the clearance is filled with steam at initial pressure and temperature and only the volume of the piston displacement can be taken from the boiler. If the compression is less than the initial the effect will be equivalent to that of filling a portion of the clearance with steam at initial pressure, and this portion will be directly proportional to the degree of compression.

From this it may be seen that a short cutoff as indicated by the high plane in which the governor revolves may admit more steam to the cylinder at each stroke than an apparently longer one, because more steam is required to fill the actually larger clearance caused by the lower receiver pressure, and consequent lower compression in the high-pressure cylinder.

In the above argument no account has been taken of cylinder condensation. About twenty per cent. of the steam which is taken from the boiler is condensed as it enters the cylinder to be reëvaporated, for the most part, only after the exhaust valve opens. The lower the pressure in the cylinder when the admission valve opens the greater will be this condensation and the greater the amount of steam admitted even for the same point of cutoff and position of the governor.

While it may not in all cases be so, it is, however, generally true that the higher the governor revolves for a given load the smaller the volume of steam required for that load, and that receiver pressure which will carry the governor the highest should be chosen.

Boiler Efficiency

When the results of a boiler test indicate an efficiency of eighty per cent. or more, the calculations are usually carried out to three or four decimal places for at least two reasons: First, those who make the test wish the accuracy of the calculations to be so impressive that the results will not be open to undue suspicion; second, they do not wish to risk the possibility of the efficiency figure being diminished by dropping too many fractional parts.

Just what boiler efficiency constitutes the world's record we do not know. Occasionally, an efficiency above eighty-four per cent. is announced; in such cases the majority of at least the unavoidable errors made are probably in favor of the boiler. An efficiency of eighty-four per cent. is so close to the theoretically possible attainment that a higher figure naturally engenders doubt as to its accuracy.

Experienced engineers disagree as to just how exact the results of a boiler test may be made. Some contend that within three per cent. of absolute accuracy is as close as it is possible to bring them; others are of the belief that within one per cent. is not impossible. It seems safe to assume that a large majority of the ordinary eight-, ten- and even sixteen-hour tests do not come within five per cent. of absolute accuracy.

It is more difficult to approach accuracy in a test with coal as fuel than with oil or gas, especially in short tests, say under forty-eight hours, for it is quite

impossible to measure the depth of the fire with any exactness and it is more troublesome to measure the fuel accurately. Where the boiler superheats the steam the test results are likely to be more accurate than where the steam is given off in a saturated condition, for in the latter case the errors applying to the calorimeter are brought in.

Of course, the personal element has everything to do with the reliability and worth of the reported results. The man who conducts a test must be experienced and capable and his integrity must be above suspicion; moreover, he must be fair-minded enough to settle uncertain points with absolute impartiality and not allow his judgments to be colored by his desire to obtain certain results.

In this issue will be found an account of two boiler tests and the results obtained. All of the circumstances surrounding these tests are conducive to the belief that the results are as nearly accurate as could reasonably be expected. The fuel was crude oil and superheated steam was generated—two factors which are in favor of close determinations—the scales, thermometers, gages, etc., were painstakingly tested and one of the boiler tests was conducted under the scrutiny of Prof. W. F. Durand, who enjoys eminence as an authority in engineering circles and an enviable reputation for fairness and carefulness. The reported efficiency of 83.43 per cent. (the average for the two tests under discussion) is a notable figure.

Power Plant Supply Analyses

No power-plant equipment is complete until it includes the apparatus necessary for the analysis of the three important materials of consumption: coal, oil and water. This apparatus, for the average plant, is not necessarily either elaborate or expensive. It may include only such instruments as will answer the one or more important questions that are of interest to the operator regarding their chief qualities. For a coal analysis that will suffice for most purposes, such as finding the content of moisture, volatile, carbon and ash, a single graphite crucible or on a pinch an iron ladle and the common platform scale are sufficient, as small quantities of any substance may be weighed on the beam of the scale.

In a turbine station where surface condensers are supplied with sea-water circulation the chief requisite so far as water is concerned is that there shall be no salt in the condensate, which is returned to the boilers. Salt makes its presence known, when burned, by an orange-colored flame, and even a trace of salt in the water is easily found by burning a single drop on the end of a clean iron wire in the flame of a spirit lamp or a bunsen burner. The nitrate of silver test for salt is quite easily and inexpensively made and has the advantage of being much less delicate, for salt must be present in a measurable amount to be revealed by the silver test, while with the burner test the slightest trace of salt is shown distinctly. Percentages in this case are not material, for any appreciable quantity of salt at all is too much.

In the matter of oil much or little knowledge may be considered necessary. But those qualities which most interest the engineer are viscosity and acidity. Viscosity is a term used to designate the comparative fluidity of oils and it conveys no information whatever unless the instrument by which the results were determined is known. The viscosity of an oil is given as the number of drops that will flow through a given orifice in a given time at a given pressure and temperature as compared with the flow of water or of some other oil. There are elaborate viscosimeters on the market, but the mentally alert engineer need not forego a reasonably accurate knowledge of the viscosity of his oil because the plant manager will not purchase an outfit for his use, because a dairy thermometer and a tin cup with a small hole in the bottom may be made to give results closely approximating accuracy. It is more often the man than the tools which determines the value of any work.

State Regulation of Water Rights

The law governing the appropriation of water for hydroelectric or other power development, passed by the California legislature in April of this year, is now in effect. The act is intended to systematize the State's water rights, and place them under the jurisdiction of a board of control at Sacramento.

The law provides that no appropriation of water for generating electricity or electrical or other power can be made for a period longer than twenty-five years, with the privilege of renewal of license for a second term of like duration. Its use is made subject to the right of the State to regulate and establish all power rates, and if appropriated for other than power development, it cannot be used for such development except under a separate and distinct filing.

It classifies as unappropriated all water which, having been duly appropriated, has not been put to some useful or beneficial purpose or leased for such service, and any such water which is not at this time in course of being used with proper magnitude in proportion to the work. Under a granted appropriation, actual construction must commence within six months from date and be reasonably prosecuted.

Applications for water appropriation must be made on blank forms supplied by the board, with detailed information. An application does not lose priority of filing through any defect if it is presented again within thirty days after rejection. Any rejection by the board is to be made within six months, allowing due time for investigation. The application fee is ten dollars and the license for water appropriation costs one hundred dollars. An additional tax is levied, to be paid to the State annually, of ten cents per theoretical horsepower developed in excess of one hundred.

Evidently California has made a good start in the right direction and if other States would fall in line there would be no need to fear the so called water trust about which there has been a great deal of agitation during the past year.

Engineers' Wages

Most general topics apparently travel in circles, occupying the center of the stage periodically, and, after being subjected to much discussion, with perhaps some gain to the cause, are relegated to the rear to make way for some question of newer interest. Such is the oft discussed question of "Engineers' Wages," utterances regarding which are now audible from certain quarters.

It is easy enough to preach upon this subject, but such preaching is apt to have little if any material effect; it is like trying to apply "absent" treatment to a broken leg. And in spite of all, the fact still remains that the engineers as a class are underpaid.

From time to time we have pointed out how an engineer may make himself more valuable to his employer and much has been accomplished by the various engineering societies toward advancing the interests and raising the prestige of the engineer. While this is a decided step in the right direction, it is not the whole solution to the problem.

Like many other lines of business, the standard of compensation is largely fixed by the supply and demand, and as long as a certain class of employers can find engineers willing to work at laborers' wages they will continue to employ them, regardless of the fact that more competent men could be had by paying a few extra dollars. The employers are apparently willing to take the chances.

Closely allied to the subject of low wages is the charge of "graft" so often hurled at the engineer. Now, frankly, we do not believe that five per cent. of the engineers would accept graft, but unfortunately the majority is often wrongfully judged by the standing of a very small minority.

It is safe to say that the greater part of those who do resort to graft are to be found among the underpaid. While this is no justification of such practice, it certainly is contributory to it, and the raising of wages would certainly do much toward stamping out the graft evil.

Heating and Ventilation

Considered as power plant problems. Layout and operation of systems and apparatus

Fan System versus Direct Radiation*

By Ira N. Evans†

From the following discussion the conclusion should not be drawn that any one of the methods should be used to the exclusion of the others as there are conditions such as size, use, location and construction, besides cost of installation and operation, which may have an equally important bearing on the choice. When the physical conditions are favorable, the author will try to show the relative economy of each method.

When air is required for ventilation in schools, office buildings and shops, the heating system in the form of direct surface in the various rooms should be capable of operation independent of the ventilating system, although heat may be supplied to both from the same source.

This point is well understood in school work where the standard method for economical operation is to heat the rooms with direct radiation and operate the blower to furnish fresh air at 70 degrees sufficient for the number of occupants during school sessions only. The direct radiation may be omitted in climates where the coldest known temperature is above 20 to 30 degrees outside, reducing the first cost without interfering with the economy of operation.

A system of ventilation is rendered unnecessary in many large shop buildings, due to the large ratio of cubic contents to the number of operatives. When direct radiation only is used in this class of building, as the heated air has a tendency to rise in proportion to the difference in temperature of the room at different levels, the roof may be several degrees higher in temperature than the floor, increasing the radiation of heat through the roof to the outside. The difficulty of obtaining positions for coils without interfering with the machinery and trenching

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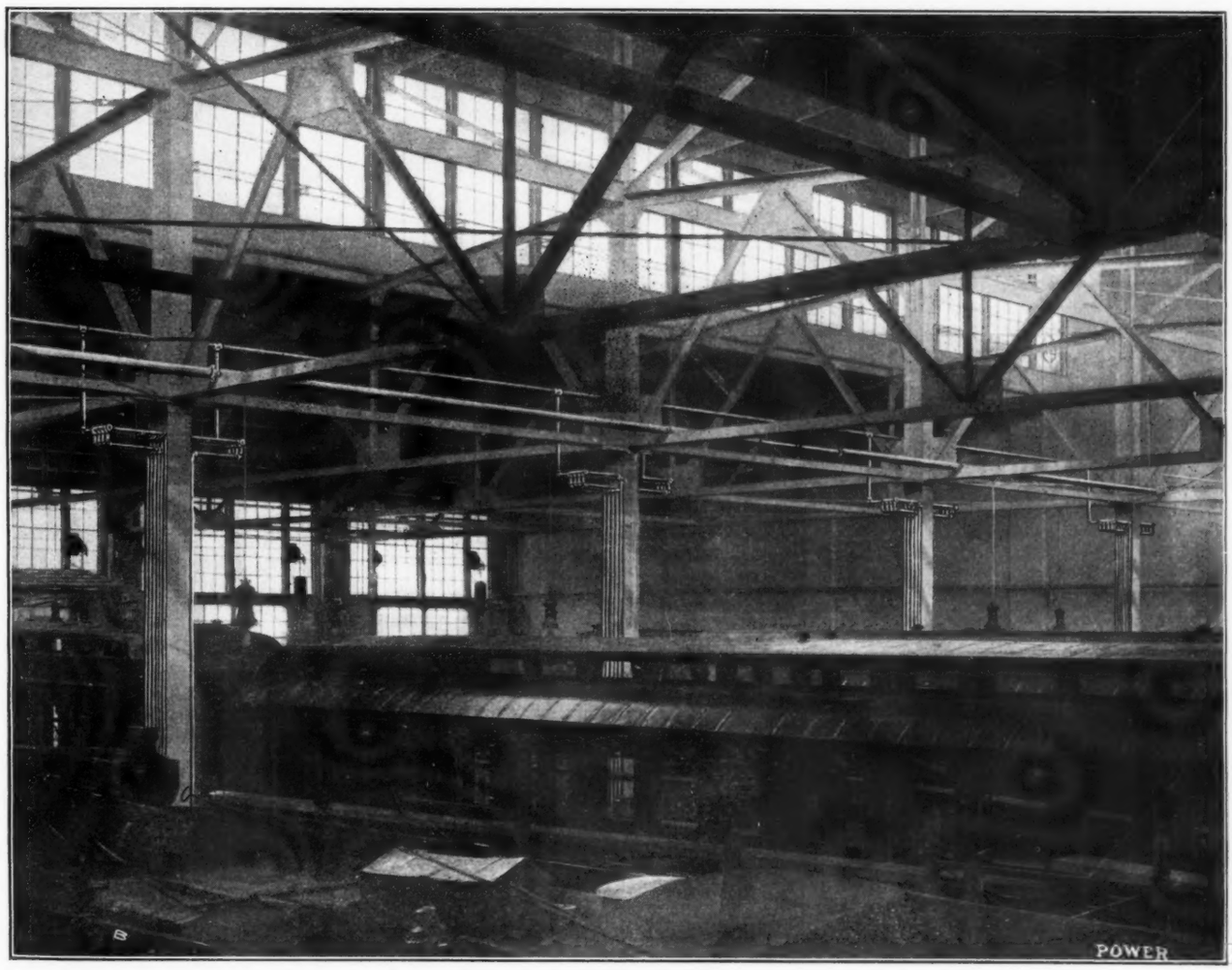


Fig. 1. Arrangement of Coils in Painting Department of the Lackawanna Railroad's Kingsland Shops

for the returns in central portions of shop buildings, is a serious matter. Overhead coils are useless when placed any distance from the floor, as the space necessary to be heated of a high shop building is that section about 10 feet from the floor. The leakage from doors and windows all falls to the floor, making the zone of greatest heat requirements the coldest part.

The fan system of heating for all classes of work is so generally understood as to need no description as to its arrangement in its general application.

The specific heat of air is about 0.24 that of water and its volume about 780 times; therefore its capacity to convey heat is limited as to distance and amount. A comparatively few units of heat will raise its temperature materially and a reduction in temperature liberates a correspondingly limited quantity of heat.

The radiation of heat from necessarily large ducts is a serious factor, and, although they may be entirely within the space heated the loss by radiation occurs at a disadvantageous point. It amounts generally to about 10 degrees per 100 feet of length, necessitating a higher initial temperature of the entering air to the extent of the drop.

The low density and specific heat of air render the boiler power in extreme weather very excessive when the hot-blast apparatus only is used for heating. The operation of the fan in circulating the air increases the natural leakage of the doors and windows, requiring greater heating capacity in proportion to the difference between the initial temperature of the entering air and the outside temperature. This initial temperature varies inversely as the amount of air circulated in proportion to the cubic contents.

In large shop buildings it is sufficient to recirculate the air through the fan and heater as the use of outdoor air would make the operating expense prohibitory. In high open buildings it is difficult to make the heated air diffuse and come in contact with cold walls and windows in order to give up its heat. Its tendency is to rise in proportion to the difference in temperature of the entering air and of the air contained in the room. This requires the circulation of large volumes of air in order to reduce the initial temperature and to obtain satisfactory results with a hot-blast system. Larger apparatus with corresponding increased first cost is the result.

Notwithstanding the above difficulties, the flexibility of the hot-air system due to the ease with which the change of the temperature of the circulating medium is effected makes it a desirable method of heating in many respects. This is especially true when the fan heaters are supplied from a general exhaust-steam system operated at nearly a constant temperature of 212 degrees. A wide range in regulation to suit variations in the outdoor temperature may be had by shutting off portions of the heater coils and varying the speed of the fan. Where a hot-water system of distribution is employed and the water temperatures are properly regulated at the plant the same necessity of manipulating the heater valves and speed of fan does not exist.

Many fan systems in industrial plants are in reality live-steam propositions a large portion of the time. The engine operating the fan furnishes sufficient exhaust steam to heat the building in moderate weather, rendering the exhaust-steam connection from the main engines

FIG. 2. BLOWER SYSTEM IN LOCOMOTIVE ERECTING SHOP

unnecessary except in extreme weather. According to data on hours taken from a previous article the period of exhaust operation would be less than 265 for the whole season.

Fan engines have a high steam consumption and a reduction in speed increases the rate per horsepower-hour proportionately. On the other hand, when the fans are operated by motors connected with the main plant the heating system becomes inoperative nights, Sundays and holidays if the main engines are not running. In a plant embracing several buildings, it would be economy to install an auxiliary unit for this purpose in the main engine room.

The combination of heating and ventilation in a fan system is commonly advocated by manufacturers of that type of apparatus to reduce the first cost, but the combination of a direct-heating system with the fan arrangement is seldom considered.

The line is sharply drawn between the recommendation of a blower system on the one hand and that of direct radiation on the other. This is due in part to business conditions, the blower manufacturer selling his product direct to the owner, when possible, without ducts or steam piping, and the steamfitter proper being obliged, in case the fan system is adopted, to buy that portion of the apparatus from his competitor.

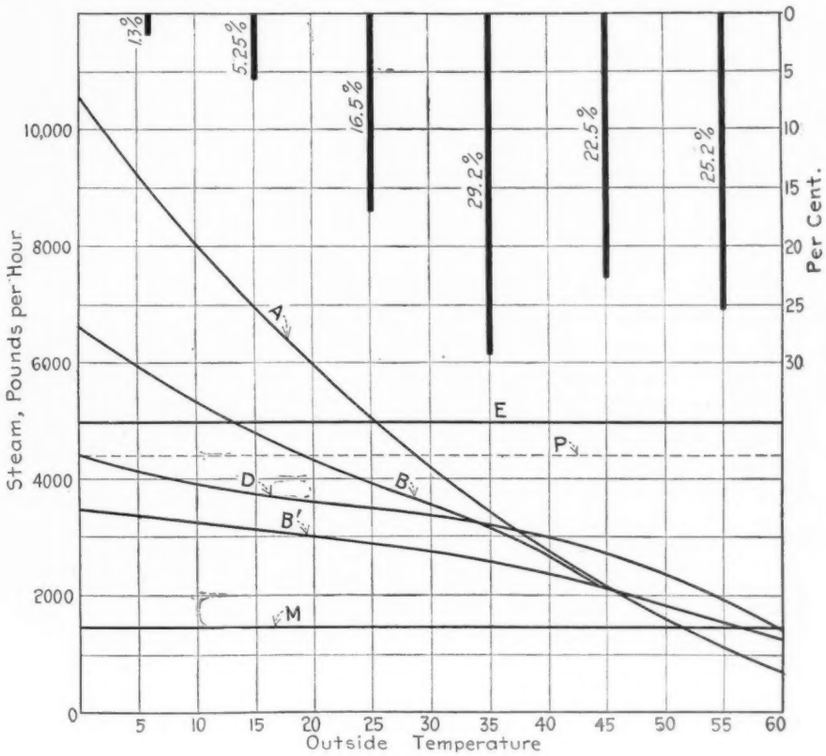


FIG. 3. STEAM CONSUMPTION CURVES FOR THE VARIOUS SYSTEMS

Due to the comparatively low temperatures of water required for condensing conditions on a hot-water system, blowers have seldom been used on account of the requisite size of heater and fan to accomplish results and lack of knowledge of the data on the design of a proper fan heater to meet the varying requirements of water temperature.

On account of the conditions just enumerated, several shop plants were designed to be heated from a central plant with forced circulation of hot water, utilizing the steam from the main engines under partial vacuum. The method of heating adopted for some of the buildings was a combination of direct radiation on the outside walls sufficient to counteract the loss of heat through the glass and wall areas, and a blower system recirculating the air over hot-water coils; the capacity of the components of the combined system being about 50 per cent. of what would be required if either system were used alone. The direct radiation was sufficient to maintain the proper temperature without the aid of the fan system at night, and when the weather outside was above 35 degrees. A higher temperature of water was used at night and a slightly lower temperature in the rooms. This arrangement allowed the fans to be operated by motors as they were not necessary at the times when the main engines were inoperative. The live-steam heater in the boiler room was used for night heating with a slightly higher temperature for the circulated water when the engines were inoperative and with the reduced heating surface in the buildings rendered the cost of night and Sunday operation a minimum. All water pipes and coils, as well as all trenches, were eliminated from the central portions of the buildings.

The fans, heaters and motors in all cases were supported in the roof trusses overhead, and arranged to take the hotter air at the roof level and blow it through the heaters and main distributing ducts in the central portion of the building to the drops at each column where the air was delivered to within 8 feet from the floor; see Fig. 2.

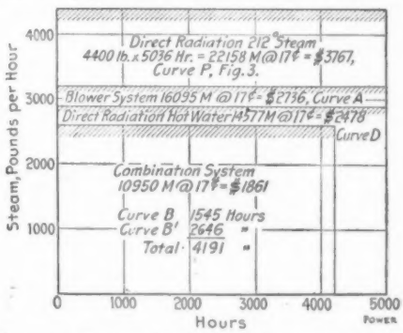

Direct Radiation 212 Steam
4400 lb. x 5036 Hr. = 22158 M @ 17¢ = $3767,
Curve P, Fig. 3.
Blower System 16095 M @ 17¢ = $2736, Curve A
Direct Radiation Hot Water 14577 M @ 17¢ = $2478
Curve D
Combination System
10950 M @ 17¢ = $1861
Curve B 1545 Hours
Curve B' 2646 "
Total 4191 "
Steam, Pounds per Hour
Hours

FIG. 4. CHART SHOWING RELATIVE OPERATING COSTS

It was found that the air diffused much better and the efficiency of the direct radiation was increased when the fan was operated. The high peak in extreme weather due to the use of a fan system alone was reduced and, although more steam was required at times than for direct radiation, the system operated on a lower temperature which enabled a higher vacuum to be carried on the main engines, and thus increased the total economy of the plant.

The Kingsland shops of the Lackawanna railroad afford an opportunity to compare the results of the direct system with that of the combination system as some of the buildings were equipped with either system on the same hot-water circuit.

The shop plant comprises about twelve buildings for the repair of cars, locomotives, etc. These are all heated and supplied with power from a central plant which contains six Stirling boilers aggregating 1500 horsepower, three Buckeye compound-condensing engines, two of 350 kilowatts capacity and one of 250 kilowatts, with the usual auxiliary machinery. There are also two air compressors requiring about 300 horsepower. All of the units have two separate exhaust connections to two mains under the floor, with floorstand valves. Any unit may be exhausted into the main connecting the large exhaust heater under partial vacuum for heating, or to the condenser direct with full vacuum without shutting the engine down.

The vacuum on the exhaust heater is regulated by a valve in the return between the heater and the condenser. Two automatic relief valves are used; one forming a bypass on the condenser between the two exhaust mains, and the other is installed at the point where the

main exhaust enters the heater. The heater connection is taken from the outboard exhaust main inside the second relief valve.

The live-steam heater is connected with a gravity return with an injector tee direct to the boilers as heretofore described for night heating, when the main engines are inoperative. This arrangement gives about 10 to 15 per cent. greater economy than when the condensation is handled by traps, pump and receiver or other methods. The boiler steam is surrounded in the heater by the circulated water and except for the slight radiation from the efficiently covered shell any loss by releasing the pressure from the condensation is impossible. Both water and steam circuits are hermetically sealed and what heat is not passed into the heating system must go back to the boiler in the condensation under nearly the same pressure and temperature as the boiler steam, only the latent heat being utilized.

This is in direct contrast to the method of reducing the boiler steam to nearly atmospheric pressure and handling the condensation by a pump or other method involving a release of pressure and loss of vapor and condensation. If the boilers were operated at 100 pounds pressure, from 70 to 210 degrees, or 140 degrees on each pound so lost. This might amount to much or little dependent on conditions, but with the arrangement recommended such losses are impossible.

These losses are due largely to the conditions of practical operation and in many cases would not appear in a theoretical discussion. They may be considerable when the vacuum pump of an exhaust-steam apparatus requires a stream of injection water as large as 1¼ inches, to cool the return, as this is entirely overflow with reference to the heating system itself.

If a live-steam heater of a hot-water system is connected with pumps or traps its economy is destroyed and the live steam may just as well be turned directly into the exhaust heater.

The pumping apparatus of the hot-water system consists of two 8-inch De Laval turbine pumps connected so as to operate singly or in series, one direct-connected to a motor and the other to a DeLaval turbine of the gearless type. The main water pipe is 8 inches in diameter, reducing as branches to the buildings are taken off, with separate returns to the header in the engine room. The mill building, carpenter shop, large locomotive shop and two passenger-car shops are heated by the combination system of blowers and direct-radiation system to 60 degrees in zero weather. The paint shops, lavatories, office building, paint and oil storage, and paint and coach annex are heated by direct radiation only; the paint shops and offices to 70 degrees and the remainder to 60 degrees.

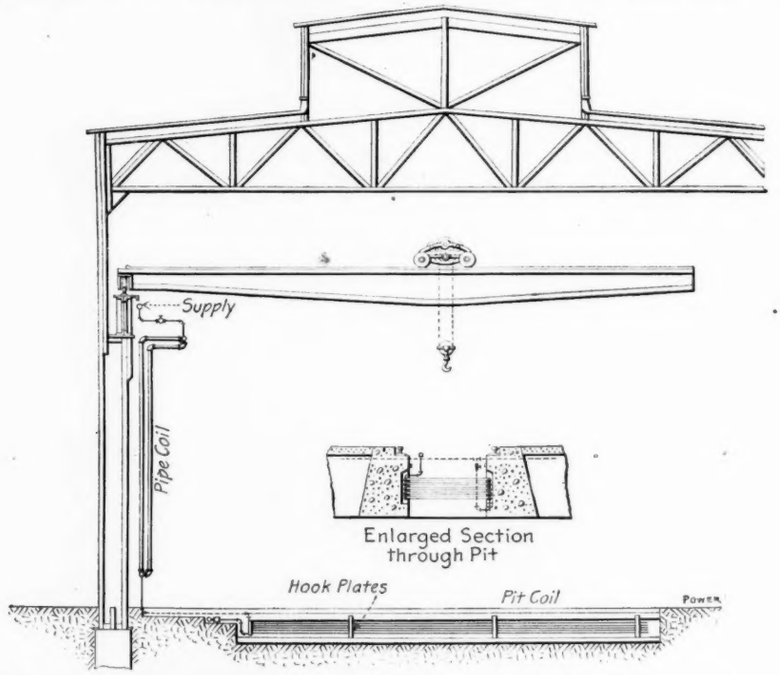


FIG. 5. ARRANGEMENT OF PIT AND COLUMN COILS IN THE LOCOMOTIVE ERECTING SHOP

or 337 degrees, and the steam were used at nearly atmospheric pressure, or 210 degrees, with the return about 170 degrees, there would be the following losses: A loss of 40 B.t.u. on each pound of steam used for heating, the loss due to wiredrawing in the reducing valve, the possible loss of the heat in the exhaust steam of the pumping apparatus. In addition all water overflowing or lost through traps or in vapor would have to be raised

In Fig. 1 is shown the arrangement of coils in the paint shops. Fans were not used here on account of the dust being stirred by the rapid movement of air and settling on the varnish. These shops were kept at 70 degrees night and day and the problem was not so much a question of heating as of reduction of the relative humidity to give a proper atmosphere for drying. The heating surface is in the

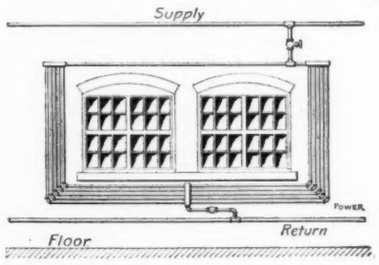


FIG. 6. WINDOW COILS IN PAINT SHOP

form of two eight-pipe coils placed vertically on each column with an overhead supply and the return pipe in a floor trench. The side walls were provided with six- and eight-pipe coils around the windows, as shown in Fig. 6.

One side of the building opened with large sheet-iron doors on the transfer table and eight-pipe double coils were placed vertically on each pilaster between the doors. In the floor near these doors one trench is provided with open gratings with several 2½-inch return pipes to counteract the draft and air leakage from this source. The heating surface was about one square foot for 125 cubic feet of space and at 70 degrees it gave satisfactory results.

The windows in the lantern were adjusted to meet conditions so a slight upward movement of air was created from floor to ceiling, at the same time curtailing the number of opened windows so as to prevent a down draft. The air was supplied mainly by the door and window leakage, which was sufficient in this case as none of the doors was tight. The large amount and vertical position of the heating surface furthered this method of procedure and gave a satisfactory drying atmosphere without the dust attendant on the use of a fan system or the unsanitary trenches to contain the heating surface in the floor, which was the scheme originally proposed. Excessively high temperatures were unnecessary to accomplish results and the plant was operated often in damp weather.

In the other buildings heated by direct radiation only, the surface was in the form of coils or radiators distributed in the regular manner on the outside walls under the windows with an overhead supply main. The return pipe was exposed on the side walls under the coils and trenched when passing under doors.

In the high shop buildings the combination system was used. Fig. 2 shows the arrangement of ducts, etc., in the locomotive-erecting shop. The air was re-

circulated over a hot-water coil of 1-inch pipe built up of cast-iron bases with elbows and nipples. A complete air change was made once in 30 minutes, and the direct radiation, placed on the outside walls only, was proportioned on the ratio of about 1 square foot to 300 cubic feet of space. The water circulation remained on the fan coils continuously whether the blowers were operated or not.

The fan motor was controlled by a switch at the floor and the only operation necessary to start the entire fan system was to throw the switch. The type of coil used for heating the air was made up in sections of 1-inch pipe and hoisted into place as a single radiator. The largest section contained 3000 lineal feet of pipe, arranged as the regular type of blower coil but modified to relieve the air automatically and give a positive water circulation.

Considering the efficiency of transmission of pipe coils over cast-iron radiator sections, the labor of assembling and making the latter tight, it is the writer's opinion that the pipe coils will prove the more satisfactory, notwithstanding a slightly increased cost. Where weight is an item of consideration the pipe coil has the advantage.

The arrangement of coils in the pits and on the columns of the locomotive-erecting shop is shown in Fig. 5. The main supply is placed overhead in the trusses supplying each coil on the column, the return from these column coils forming the supply to the pit coil, which later was connected into the main return in the floor trench.

The locomotive shop was of the regular design, with pits in each track entering through the doors from the transfer table. The projection of the pipes from the sides of the pit rendered the fittings and hook plates liable to be broken by heavy weights. To obviate this difficulty the concrete was recessed on each side as shown, and the hook plates, reversed, were fastened to the side walls by heavy iron cleats, arranged so as to make the side of the pit and the pipe coils flush, with no projections. This arrangement proved very satisfactory, and is recommended for roundhouse work when supplemented with a hot-air supply. On the side walls of the machine-shop portion of the building the window coils were made and connected as shown in Fig. 6.

The curves in Fig. 3 show the relation of the hourly steam consumption of a blower system, a system of direct radiation and a combination system. The data shown in Table 1 were obtained from experience on several installations where hot water was used. A log was kept for several months during the heating season, so the quantities given are fairly accurate. The curves are worked out for the actual steam required for heating without involving the transmission losses from the main plant or the steam consumption of the engines when using exhaust steam; the general relation would be true whether exhaust or live steam or hot water were used.

Table 1 gives all the data for Figs. 3 and 4, the number of hours being taken from a table in the September 12 issue, as in Table 2.

Curve *A*, with pounds of steam as ordinates, and outside temperatures as abscissas, gives the steam consumption per hour of a blower system. The data are taken from Sturtevant's "Heating and Ventilation." This involves an air change every 14 minutes and 140 degrees as the temperature of the entering air necessary to heat a building to 70 degrees in zero weather. If the air is recirculated the rise is 70 degrees and if outdoor air is used it would be 140 degrees in zero weather. In the book referred to a series of curves give factors showing the percentage of this amount of heat required in weather above zero, regulation being effected either by reducing the speed of the fan or by lowering the temperature of the entering air by shutting off part of the heater coil. For this comparison the building is figured to be heated to 70 degrees, the air is recirculated in each case and continuous operation is intended. All fan-heating guarantees are based on continuous operation. The building taken as an example has 2,080,000 cubic feet of space and is the passenger shop at Kingsland with the apparatus changed to give 70 degrees instead of 60 degrees. A change once in 16 minutes gives 130,000 cubic feet of air at 140 degrees as the amount required in zero weather per min-

TABLE 1. COMPARATIVE DATA ON BLOWER SYSTEM, DIRECT RADIATION AND THE COMBINATION SYSTEMS

Blower System					Direct Radiation					
Outside Temperature, Degrees F.	Temperature Factor	Steam per Hour, Pounds, Curve A	Hours	Steam per Season, Pounds	Average Water Temperature, Degrees F.	Vacuum	Temperature Difference of Pipes and Room	Hours	Steam per Hour, Pounds, Curve D	Steam per Season, Pounds
0–10	0.85	9,282	66	612,612	205	3″	135	66	4,131	272,646
10–20	0.65	7,008	264	1,850,112	195	1″	125	264	3,825	1,009,800
20–30	0.47	5,132	829	4,254,428	185	7.5″	115	829	3,519	2,917,251
30–40	0.3	3,276	1,471	4,818,996	175	12″	105	1,471	3,213	4,726,323
40–50	0.2	2,184	1,131	2,470,104	160	18″	90	1,131	2,754	3,114,774
50–60	0.15	1,638	1,275	2,088,450	135	23″	65	1,275	1,989	2,535,975
Totals	....	.....	5,036	16,094,702	...	.....	.....	5,036	.....	14,576 769

Combination System (Day Heating)										Combination System (Night Heating)				
Outside Temperature, Degrees F.	Average Water Temperature, Degrees F.	Vacuum, Inches of Mercury	Temperature Difference of Pipes and Room, Degrees F.	Rise in Temperature of Circulating Air, Degrees F.	Hours	Steam per Hour—Direct Radiation, Pounds	Steam per Hour, Blower, Pounds	Total Steam per Hour, Pounds, Curve B	Total Steam per Season, Pounds	Average Water Temperature, Degrees F.	Temperature Difference of Pipes and Room, Degrees F.	Steam per Hour, Curve B′	Hours	Steam per Season, Pounds
0–10	190	4	120	50	10	1,944	3,900	5,844	58,440	215	155	3,348	56	187,488
10–20	180	10	110	40	50	1,782	3,120	4,902	245,100	205	145	3,132	214	670,248
20–30	170	18	100	30	205	1,620	2,340	3,960	811,800	195	135	2,916	624	1,819,584
30–40	150	14	80	25	500	1,296	1,950	3,246	1,623,000	180	120	2,592	971	2,516,732
40–50	160	20	90	..	350	1,944	.....	1,944	680,400	160	100	2,160	781	1,686,960
50–60	140	22	70	..	430	1,512	.....	1,512	650,160	140	80	.....	.....	.....
Totals	...	..	...	..	1,545	.....	.....	.....	4,068,900	...	...	.....	2,646	6,881,012

TABLE 2. TOTAL HOURS IN DAY AND NIGHT OPERATION

Degrees	Combination System Night Operation, Hours	Combination System Day Operation, Hours	Continuous Operation of Blower and Direct Radiation
0–10	56	10	66
10–20	214	50	264
20–30	624	205	829
30–40	971	500	1471
40–50	781	350	1131
50–60	....	430	1275
	2646	1545	5036

ute. The factors and other data are given in Table 1 and plotted as described; 50,000 cubic feet is the amount of air one pound weight of steam will raise one degree. Thus

$$\frac{130,000}{50,000} \times 70 \times 60 = 10,920 \textit{ pounds}$$

of steam per hour are required in zero weather. This quantity multiplied by the factors in each case gives the data for curve *A*, Fig. 3, and Table 1. The hours for the different periods for the whole season were determined as shown in a previous article.

To operate this fan with an engine, allowing for friction and other losses, will require approximately 100 horsepower, which at 50 pounds per horsepower-hour would mean 5000 pounds of steam per hour, plotted on line *E*, Fig. 3.

Curve *D* shows the requirements for direct radiation applied to this building from data of the paint shop, which is practically part of the same building. A transmission is used of 1.8 B.t.u. per hour per square foot per degree difference between the temperature of the pipes and the air of the room heated to 70 degrees.

The direct surface will be taken at 17,000 square feet, or at the same ratio (1:125) as for the paint shop for 70 degrees, with continuous operation for 5036 hours. Thus

$$(17,000 \times 1.8) \div 1000 = 30.6 \textit{ pounds.}$$

of steam per hour per degree difference in temperature between the pipes and the room gives the data for curve *D*, Table 1. The latent heat is taken as 1000.

Curves *B* and *B'* were plotted from data on the combination system of direct radiation on the outside walls and a blower system recirculating the air. The water and air temperatures shown in Table 1 are the actual readings on several jobs with the same proportion of heating surface. An air change of once in 30 minutes requires 65,000 cubic feet of air per minute, and the direct radiation totals 9000 square feet or one square foot to 230 cubic feet of space.

The power required to operate the fan was about 50 horsepower, which at 35 pounds of steam per horsepower-hour would mean 1750 pounds. This was based on a 40-horsepower motor operating on current from the main engines, including all losses—line *M*, Fig. 3. Steam for fan operation is disregarded unless it can be considered as exhaust steam used for heating. It has been indicated in Fig. 3.

The transmission for the direct radiation and steam rate for raising the air temperature are taken as before and shown in Table 1 under combination system. Thus, as before,

$$(9000 \times 1.8) \div 1000 = 16.2 \textit{ pounds.}$$

per hour for each degree difference between the air of the room and the pipes when the fan is operative. The air, using the same quantities as before, would require

$$\frac{65,000}{50,000} \times 60 = 78 \textit{ pounds}$$

of steam per hour for each degree rise in temperature. The total number of hours of day operation is 1545 from the table previously referred to. The sum of the pounds of steam for the direct radiation and the air supply for each 10-degree period form the ordinates for curve *B*, Fig. 3 and Table 1.

The night operation and the last two items in the column of total steam for combination day heating, Table 1, when the fan is inoperative, include the fan coil of 3000 square feet as direct radiation, making a total of 12,000 square feet. There is a gravity circulation of air through the ducts and coil when the blower is shut down sufficient to warrant this method of figuring.

The direct radiation under these conditions would require with the same transmission

$$(12,000 \times 1.8) \div 1000 = 21.6 \textit{ pounds}$$

of steam per hour per degree difference of temperature of room and pipes.

In the case of the night heating the room is allowed to cool somewhat below 70 degrees. The transmission is taken at a room temperature of 60 degrees and the system discontinued below 50 degrees outside temperature. This gives a higher steam consumption for a given amount of surface than if 70 degrees were used. The hours for night heating total 2646.

The fan system shows high economy in moderate weather, but the peak of the load in extreme weather shows a great increase in the necessary boiler power. The ordinates of curve *A*, Fig. 3, would be doubled if outdoor air were used. The high peak is due to the high temperature and large volume of air increasing the building leakage in extreme weather. Decreasing the volume requires a higher temperature of air and its tendency to ascend to the roof level is greater, endangering the efficient operation of the system. At the same time this is one way of reducing the first cost of a blower system by installing smaller apparatus. Decreasing the size of ducts and increasing the velocity of air is another method, but this increases the power necessary to drive the fan.

When the first cost of an apparatus is the main object rather than operating expense, it might pay to operate the fans with engines, condensing the main engines and using live steam on the fan coils in conjunction with the exhaust from the fan engine. This would give a very flexible plant and except for the high peak a small percentage of the time and the fact that the exhaust from the main engine could not be used would be nearly as economical in use of steam as a hot-water system operated with live steam. In industrial plants operating days the exhaust is only available 30 per cent. of the time against 70 per cent. when live steam is required in any case. The first cost of this plant with small high-pressure mains makes it very attractive in some cases as there would be plenty of pressure to remove the air and return the condensation.

In arranging a fan system to operate on a forced hot-water circulation system. Curve *A* would remain the same but the fans and heater would have to be increased in size to enable the temperature of the water to be reduced within the limit of the exhaust steam when taken under partial vacuum from the main engines.

Some high shop buildings have been arranged with a hot-blast system for heating in the basement with underground ducts discharging at the floor level. The radiation losses from underground ducts are very great and if the air is recirculated through gratings in the floor, the arrangement is apt to be unsatisfactory. The warmer air will rise to the roof to stay, and the air supply to the fan will probably be the leakage from open doors and windows. This rush of colder and heavier air over the floor to the fan inlet will tend to make the working zone of the building uncomfortable when the apparatus is operated at its greatest capacity.

In curve *D* note the reversed shape for direct radiation. This is caused by the humidity of the atmosphere which is maximum at about 30 degrees outside temperature when snow is at the point of melting. This humidity would be the determining point between 25 and 35 degrees outside temperature whether the fans on the combination system should be operated or not, as the dampness would cause a chill even when the radiation might be at the proper water temperature for this outside condition.

This humidity within the building would disappear immediately on starting the fans.

The cost of operating the fans on the combined system is about one-half that of the blower system and the peak is also materially reduced. The use of the direct radiation at night and eliminating the fans in moderate weather make these periods a minimum for operating expense. The maximum temperature of the air on the combined system is not over 120 degrees in zero weather and 50 per cent. in amount as required for the hot-blast system. This combination allows lower water temperatures and higher vacuums to be carried on the main engine, as shown by Table 1. For a temperature of 0 to 10 degrees the direct radiation requires 3 pounds back pressure while the combination system shows 4 inches of vacuum.

With the combination system it is possible to raise the temperature of the

building quickly as soon as the exhaust is available in the morning as the ducts are full of warm air due to the fan coil being in continuous operation. This enables the heating in the morning to be done by exhaust steam rather than with live steam without appreciably increasing the water temperature and reducing the vacuum as would be the case with the other two systems.

A study of the curves in this and in previous articles will indicate that many systems of heating by direct radiation, on low pressure or vacuum, are inadequate to give a comfortable temperature in extreme weather unless a prohibitive back pressure is produced, in order to raise the temperature of the heating surface. Therefore the buildings are cold during the few hours of extreme weather or are overheated in moderate periods.

The same is true where the blower system is used without direct radiation, although overheating in moderate weather is a more common experience and undoubtedly due to carelessness in not shutting off the heater coils.

The hot-water system of circulation enables the main engines to be operated more economically under condensing conditions and the radiation can be regulated by changing the temperature of the water at a certain point in the engine-room. Where the direct radiation, however, is limited, as in the combination system on low-pressure steam, there would not be a very great change in the steam consumption of the direct radiation; see curve B' under the combination system, Table 1. The main regulation would be in the fan system.

The conclusion would be drawn that the major portion of the saving in Fig. 4 outside of the engine question, could be made on any blower job by adding direct radiation to be operated on live steam, nights and Sundays, or 70 per cent. of the time, and reduce the speed and power of the fan one-half, shutting off a portion of the fan coil and only operating the latter by motor 25 per cent. of the time when exhaust steam was available from the main engines.

Where a plant is equipped with direct radiation part of the heating surface could be removed and a fan system as described added to make up the difference and a corresponding saving would be effected.

In the case of additions to a plant, this method would enable extensions to be made and sufficient exhaust steam would be available to the extent of the saving.

In Fig. 4 the total areas represent the pounds of steam per season, or cost of operating the four systems. The ordinate in each case is the average pounds of steam found by dividing the total amount per season in Table 1 by the total hours. At 17 cents per 1000 pounds of steam (from a previous article based on $3 per ton for coal and nine pounds of evaporation) the costs are found to be as follows:

Direct radiation, low-pressure steam, 212° (curve P)	$3767
Blower system, curve A	2736
Direct radiation, hot water, curve D	2478
Combination system, curves B and B'	1861

The system of direct radiation would cost about the same as the blower system when all items of flues and steam piping were included. The combination system would cost not over 15 per cent. more. The two points are again emphasized, that the system which can save nights by varying the temperature of the medium to suit outside weather conditions is the one which will show the greatest economy; also, that the saving due to using exhaust steam is only incidental due to the few hours of operation in the ordinary plant. The introduction of two shifts, night and day, would change the whole aspect of the problem and increase the importance of exhaust-steam operation. It must be understood that these savings are indicated for live steam only and that the true saving on the plant could not be determined until these curves of operation are combined with the conditions of engine operation as discussed in a previous article.

TABLE 3

Systems Compared	Saving	Per Cent.	Principal on Which Saving Pays 15 Per Cent. per Year
Combination system over direct steam, 212°	$1,906	50	$12,500
Combination system over blower system	875	32	5,830
Combination system over direct radiation, hot water	617	25	4,100
Direct radiation, hot water, over direct steam, 212 degrees	1,289	34	8,600
Direct radiation, hot water, over blower system	258	9.4	1,720
Blower system over direct steam 212°	1,031	27	6,900

Line P shows the steam consumption of a low-pressure steam system with the medium at 212 degrees and all surface turned on. The hours of operation may be curtailed due to overheating, but the general custom is to open doors and windows, thus increasing the cost for steam. Many large plants shut down nights, using high-pressure steam a few hours in the morning to heat up the buildings before the engines are in operation, but, except for labor, there is no saving in this method.

The water circulation relieves operatives of the necessity of going to each building to shut off fan coils or radiators, which would have to be done if economy were desired.

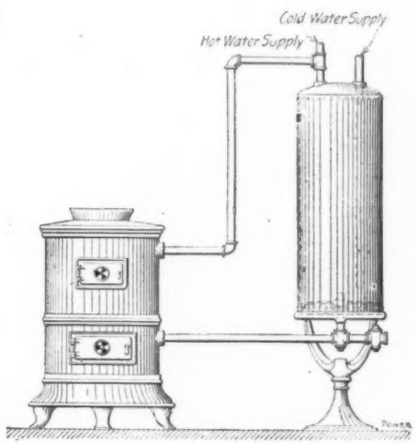
With the reduction of boiler power at the peak load and a more economical vacuum on the main engines, the combination system will show a handsome saving over any increased cost.

The data in Table 3 show the amount of money which it would be policy to spend to obtain the advantages of saving of one system over another and pay 15 per cent. interest and depreciation on the investment.

LETTER

Connections of Range Boiler

I think Roy V. Howard, whose letter appears in a recent issue, is mistaken when he states that it is the usual practice to connect the discharge pipe from the heater to the side hole in a range boiler. As for his statement that the hot-water pipe from the heater is



ARRANGEMENT OF HEATING BOILER

usually connected to the bottom of the reservoir, he is certainly making a misstatement, no doubt unintentionally. I have seen hundreds of heaters connected to reservoirs in private houses, public buildings, factories, etc., both in Canada and in the United States, during the past 25 years, and I have yet to see one system with the discharge pipe from the heater connected to the bottom of the reservoir. If a man attempted to connect a system in this manner he would show himself to be entirely ignorant of the first principles of hot-water heating.

I agree with your correspondent that many heater discharge or circulating pipes, especially in private houses, were at one time usually connected to the side hole about half-way up the range boiler, the cold water going to the heater from the bottom of the range boiler. The usual and proper way to connect up a water heater is shown in the accompanying illustration.

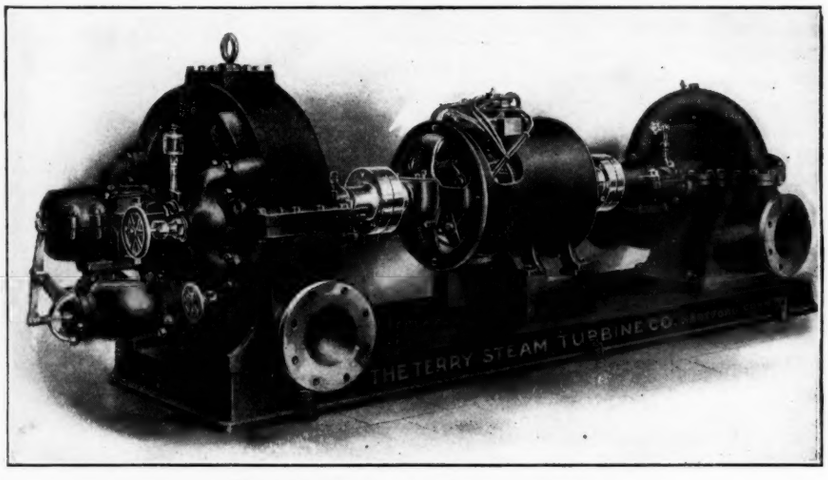
JAMES E. NOBLE.

Toronto, Ont., Can.

An Unusual Pumping Set

There has recently been installed by the West Boylston Manufacturing Company in their cotton mill at Northampton, Mass., a combination pumping and electric-generating set which embodies some unusual features. The unit consists of a 75-horsepower Terry steam turbine direct connected to both a 30-kilowatt Diehl direct-current generator and an 8-inch double-suction Jeanesville pump. The generator is situated next to the turbine with the pump connected beyond. Flexible couplings are employed between each two machines so that it is possible to cut out the pump and run the generator alone. The conditions are such that no occasion arises for running the pump without the generator, which accounts for the tandem arrangement.

The pump is employed in circulating the hot water of the mill-heating system, while the generator furnishes excitation for the main generators which furnish the power for the mill motors during the day. At night, the generator is switched over onto the lighting circuit of the mill and thus the load on the turbine is a 24-hour one at practically all seasons of the year. During the winter it is necessary to run both the generator and pump at all times. In the summer as soon as the heating load goes off, the pump is disconnected and the generator operated alone. This set runs at 2600 revolutions per minute and the turbine is operated noncondensing, the exhaust being used in the summer for boiler feed and in the winter for heating the water of the hot-water heating system.



TURBINE, PUMP AND GENERATOR UNIT

Oregon Water Power License Law

The law for the regulation of water-power appropriation in Oregon, known as the Water-Power License Act, passed during the recent session of the legislature, has become effective. It is primarily for the purpose of securing information regarding water-power rights instituted before the adoption of the State water code and water-power tax law of 1909, applying only to such plants as have appropriated water to advantageous use prior to May 22, 1911.

The law requires that all such plants file statements with the State engineer by January 1, 1912, giving complete information of the extent of the claim of water appropriated. Commencing from that date, the following graduated fee becomes due and must be remitted annually to the State: For each theoretical horsepower up to and including 100, ten cents; from 100 to 1000, five cents; in excess of 1000, one cent. This tax becomes a lien upon the plant through nonpayment, and is collectable with proportional additional sum as penalty by the attorney-general.

The fee is waived where the total claim does not exceed 25 horsepower, provided a statement has been filed, and in cases where the water is appropriated for development by the United States, the State or any municipal corporation. The sum derived from this law will be applied to a general survey fund for State hydraulic-engineering work.

Historic Engine Sold for Scrap

One of the largest transactions in second-hand machinery in Chicago in many years was recently reported by the *Iron Trade Review*. The Pullman Company sold to the Oakdale Iron Company, Chicago, 23 old engines, making about 30 carloads in all. In this purchase made by the Oakdale Iron Company, there was included a large Corliss engine that was exhibited at the Philadelphia Centennial in 1876 and was used for many years at the Pullman Company's works.

Thousands of people have seen this engine in operation, which, although rated at only 1400 horsepower, weighed over 650 tons. The engine will be removed to the yards of the Oakdale Iron Company at Ninety-first street and the Belt railway, where it will be broken up. Many of the parts of this engine will be sold for use again and the rest will find its way to the scrap pile. This no doubt is one of the largest transactions in this line in Chicago since the world's fair material was sold. It has been suggested that this engine ought to be preserved intact in the Field museum, as the Pullman Company might donate it in the interests of science instead of selling it for scrap.

BOOKS RECEIVED

POWER PLANT TESTING. By James Ambrose Moyer. McGraw-Hill Book Company, New York. Cloth; 422 pages, 6x9 inches; 271 illustrations; tables; indexed. Price, $4.

PRACTICAL THERMODYNAMICS. By Forrest E. Cardullo. McGraw-Hill Book Company, New York. Cloth; 411 pages, 6x9 inches; 223 illustrations; tables; indexed. Price, $3.50.

MACHINE DRAWING AND SKETCHING FOR BEGINNERS. By J. H. Robson. D. Van Nostrand Company, New York. Cloth; 196 pages, 5x8 inches; 314 illustrations; indexed. Price, $2.

THE DESIGN OF STATIC TRANSFORMERS. By H. M. Hobart. D. Van Nostrand Company, New York. Cloth; 174 pages, 5½x8½ inches; 101 illustrations; tables; indexed. Price, $2.

DIRECT AND ALTERNATING CURRENT MANUAL. By Frederick Bedell. D. Van Nostrand Company, New York. Cloth; 360 pages, 5¼x8½ inches; illustrated; tables; indexed. Price, $2.

ELECTRIC TRACTION AND TRANSMISSION ENGINEERING. By Samuel Sheldon. D. Van Nostrand Company, New York. Cloth; 307 pages, 5¼x7¾ inches; 127 illustrations; tables; indexed. Price, $2.50.

ELECTRIC CENTRAL STATION DISTRIBUTION SYSTEMS. By H. Barnes Gear and P. Francis Williams. D. Van Nostrand Company, New York. Cloth; 347 pages, 5¼x8¼ inches; 139 illustrations; tables; indexed. Price, $3.

PERSONAL

H. W. Deininger, formerly Iowa representative of the Globe Machinery and Supply Company, has accepted the position of general manager of the Sac City Electric Company, Sac City, Iowa, succeeding R. W. Richardson, who goes with Byllesby & Co., at St. Paul, Minn.

Moments with the Ad. Editor

A department for subscribers edited by the advertising service department of Power

Dr. J. S. Abbott, Food and Drug Commissioner of Texas, gave a lecture the other day at the Pure Food Congress, at Madison Square Garden, New York.

Dr. Abbott talked about food adulteration.

He said that the desire of a great many American people for *pretty* foods is much more the cause of food adulteration than anybody dreams.

People want snowy white flour; therefore, Dr. Abbott said, the miller bleaches it with oxide of nitrogen.

People want bright green peas; therefore they are colored with copper sulphate.

People want bright red sausage; therefore it is painted with Bismark brown.

People want rice with the outer coat removed, because it is *prettier*; therefore the part of the rice containing the most nourishing qualities is stripped off.

It has been thought that the adulteration of food was due to the hard-hearted greed of manufacturers. But apparently they are not so much to blame as was supposed.

Manufacturers advertise "pure white flour," "bright yellow butter," "bright green peas," not always because it is cheaper to make the things that way, but because they will sell better that way.

That illustrates the power of public opinion, *through* advertising, on the advertiser himself.

But the interesting thing about the Texas Food and Drug Commissioner's speech is yet to come.

He said that in order to waken the people of the West up to the character of the food they had been demanding, he was going to use the same means by which the people had learned that they could secure those pretty foods—the press.

Once people decide they want good food, they get it.

Once people *decide* they want good anything—clothes, furniture, machinery—they get it.

The high-class technical paper has as its only purpose to tell in its news columns what is the difference between "good" and "near good" in material, equipment and methods, and the advertising columns have as their only purpose the telling *where* those "good" things are to be got.

No advertiser is going to buy space to talk to men who know the difference between "good" and "near-good" about something that is only "near-good."

Even if the publication will let them.

And POWER will not.

The advertisers in this Selling Section are not only not admitted except when they have something *good* to sell, but they are firms progressive enough to have realized long ago there would be no use talking about anything else.

BUSINESS ITEMS

The Nashua Machine Company has appointed the Griscom-Spencer Company, 90 West street, New York, selling agents for the Bundy steam traps for Greater New York.

The Buffalo Forge Company, Buffalo, N. Y., has recently been awarded the contract by the Westinghouse Air Brake Company for the heating and ventilating system in its new carpenter shop at Wilmerding, Penn. The building will be of brick construction and 210 feet long.

The Westinghouse Electric and Manufacturing Company has recently furnished two 75-kilowatt, direct-current, engine type generators for installation in the McKinley manual-training school at Washington, D. C. This school is under the direction of the commissioners of the District of Columbia. This order represents an addition to the plant already installed in the school, which consists of a Westinghouse direct-current generator.

The Rateau Steam Regenerator Company, 140 Cedar street, New York, has been awarded a repeat order by the American Sheet and Tin Plate Company for a steam regenerator for its Vandergrift (Penn.) plant. This regenerator will receive an intermittent flux of steam from reversing mill engines and will deliver a constant flux of steam to two mixed flow steam turbines of 500 kilowatts each. It has also been awarded a contract by the Atlanta Steel Company for a steam regenerator for its Atlanta (Ga.) plant. This regenerator will receive steam from reversing engines and also from a 3-high mill engine. The steam is to be delivered by the regenerator to two mixed flow turbines of 500 kilowatts each. In both instances the mixed flow steam turbines are equipped with the Rateau patent mixed-flow governor.

Prominent among the exhibitors at the American exposition of brewing machinery, materials and products, which will be held at the Chicago Coliseum, October 12-22, is the Schaeffer & Budenberg Manufacturing Company, of Brooklyn, N. Y. As usual it will show a complete line of its high-grade engineering instruments. A leader among these is its new recording thermometer, its special features being the mercury-filled steel capillary tube and the night and day chart, both new departures in the thermometer construction. A full line of its brewers' thermometers together with steam and ammonia gages for indicating and recording purposes will be shown. Its new steam-engine and ammonia compressor indicator will be made prominent by its many improvements. Another instrument will be its reform thermometer and an attractive display of engine-room clocks will help toward making this exhibit exceedingly interesting.

NEW EQUIPMENT

Port Hope, Ont., will install a new waterworks system.

Port Stanley, B. C., will equip a hydroelectric station.

Bridgeton, N. J., is constructing a new pumping station.

Wapato, Wash., will install municipal waterworks system.

Woodland, Cal., contemplates installing new pumping machinery.

Armstrong, B. C., will equip a complete new waterworks system.

The Beatrice Creamery Company, Topeka, Kan., will install stokers.

The Hardin Wyandot Light Company, Kenton, Ohio, will build a new plant.

Crewe, Va., will issue $25,000 bonds for improving water and lighting systems.

Frank Cavney, 619 South East street, Indianapolis, Ind., will install a boiler.

The Hazelton (B. C.) Water, Light and Power Company will equip a new plant.

The Long Island Lighting Company is building a power house at Northport, L. I.

The Indianapolis (Ind.) Water Company will erect an addition to its pumping station.

The cold-storage plant of F. J. Hoerr, Mankato, Minn., was destroyed by fire. Loss, $4000.

The American Dredging Company, Camden, N. J., will erect a power house and coal pocket.

Dothan, Ala., will issue $70,000 bonds for improvements to its water and lighting systems.

The Agricultural College, Logan, Utah, is taking bids for the erection of a hydroelectric power plant.

The Ironton (Ohio) Electric Company has increased its capital and will improve its power plant.

The Diamond Ice Company, Seattle, Wash., will erect a modern refrigerating plant to cost $125,000.

The Seattle, Renton & Southern railway, Seattle, Wash., will build a new substation on Rainier avenue.

Bids are out for a power plant to be built for the Bureau of Standards on the Pittsburg (Penn.) Arsenal property.

The city of Redlands, Cal., will install a new high-pressure waterworks system. About $52,000 will be expended.

The Eastern Canada Power Company will equip a new power house at Navens Falls, near Murray Bay, Quebec.

The Niagara Ice Company, Niagara Falls, Ont., will install a complete new cold-storage and ice-making machinery.

The city council, Shelbyville, Ind., has appropriated $8000 for purchasing new equipment for the city pumping station.

CATALOGS WANTED

W. E. Pettengill, supervising engineer for the Hockanum Mills Company, Rockville, Conn., would like to receive catalogs of power-plant equipment for filing.

HELP WANTED

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

INSIDE WIRE MEN, first class only. The Julius Bentyen Electric Co., Ironwood, Mich.

WANTED—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. Address "M. M. Co.," POWER.

AN ENGINEER in each town to sell the best rocking grate for steam boilers. Write Martin Grate Co., 281 Dearborn Street, Chicago.

AGENTS WANTED for first-class steam specialty in use throughout United States. Address C. S. Wood, 410 S. 15th St., Philadelphia, Penn.

TWO DRAFTSMEN WANTED, preferably with some experience on Corliss engines; state full information in letter; eastern city. Address Box 512X, POWER.

WANTED—Representative in New England territory for well known automatic feed water regulator. Address "Vigilant," 410 Harrison Bldg., Philadelphia, Penn.

ENGINEER wanted in every city to sell Lippincott indicators, and instruct buyers; see advertisement, page 77, POWER, October 3. Address Lippincott Co., Newark, N. J.

THE VULCAN SOOT CLEANER offers an exceptional opportunity for power specialty salesmen. For further particulars address G. L. Simonds & Co., 802 Steinway Bldg., Chicago, Ill.

ONE ENGINEER in each town to represent us, your choice of any indicator outfit on the market as a free premium; give your home address and firm employed by. The Olson Mfg. Co., Manitowoc, Wis.

WANTED—Young man, machinist by trade, strictly sober and steady, to take position as engineer in gas producer plant operating seven days, nine-hour shifts; experience not as essential as ambition to learn. Box 511, POWER.

WANTED—One first-class marine engine and boiler draftsman, $5.04 per diem; a competitive examination will be held for the above position, October 18. For further information address "Commandant," Navy Yard, Charleston, S. C.

AGENTS WANTED—To sell lubricating oils, belts, hose, paint and varnish, for power machinery, to factories, mills, auto owners, stores, threshers; exclusive territory to right party; oil experience unnecessary. Manufacturers Oil & Grease Co., Cleveland, Ohio.

STEAM ENGINEER to take charge of power plant, New England paper mill, operating one thousand engine horsepower; none but thoroughly competent engineers need apply; references required; state salary and present employment, signed. "Steam Engineer," Care POWER.

AN ENGINEER; one who has had at least ten years' power station experience and understands boilers, turbines, engines and general uptodate apparatus; an engineer in charge of a medium size generating station; salary $2000 per year or over to the right man; answer, giving age, experience and copies of references. Box 503, POWER.

SITUATIONS WANTED

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

POSITION WANTED as assistant engineer in large power plant; age 23; six years' experience with traction and stationary engines; good reference. Geo. E. Hilgert, Pilot Knob, Ind.

AS CHIEF in plant of 1000 horsepower or smaller, or as assistant in larger; have fair technical education, first-class Indiana license and six years' continuous experience in the engine room; satisfaction guaranteed; 26 years old, married and strictly temperate; can furnish good reference; am employed at present as hoisting engineer. Address Box 500, POWER.

MISCELLANEOUS

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

PATENTS—C. L. Parker, Patent Attorney, ex-examiner Patent Office, 904 G St., Washington, D. C. Write for Inventor's Handbook.

WANTED—A De La Vergne fuel-oil engine of 85 or 100 horsepower; must be in good condition. Address Kraeuter & Co., 18th Ave., Newark, N. J.

EVERY ENGINEER should be posted regarding the new system of vacuum heating installed without payment of royalty; I have valuable information; write today. T. L. Reeder, 1417 W. Jackson Blvd., Chicago, Ill.

FOR SALE

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

FOR SALE—Brand new Robertson-Thompson indicator outfit, complete; never been used. Box 187, West Hurley, N. Y.

FOR SALE—8x10 Skinner engine, direct connected to 30-kilowatt generator, and 8x10 Allfree engine, direct connected to 20-kilowatt generator. Address "Engineer," Box 2, Station A, Cincinnati, Ohio.

MACHINERY FOR SALE—One Worthington pot pattern hydraulic pump 10x4½x10, capacity 300 pounds complete with regulating valve, brass gage, Detroit lubricator; receiving tank 6 feet by 36 inches, etc. Menier, 358-364 Seventh Street, Hoboken, N. J.

FOR SALE—One patent Berry boiler; capacity 100 horsepower good for 125 pounds working pressure; free from scale and recently retubed and is in A No. 1 condition. Henry H. Sheip Mfg. Co., Columbia Avenue and Sixth street, Philadelphia, Penn.

TWO SETS (two wheels to each set) Hercules, bronze water wheels, with wheel cases;

wheels 24 inches diameter, on horizontal shafts; made by Holyoke Machine Company; capacity, approximately 600 horsepower, under 50 feet head; in good condition, having been used less than five years. J. E. Henry & Sons Co., Lincoln, N. H.

FOR SALE—Almost new; machinery to be removed from amusement park; only operated two years; steel smoke stack with induced draft equipment, suitable for 600 to 800 boiler horsepower; 75-kilowatt alternating-current generator, 2300 volts, 60-cycle, 3-phase, 900 revolutions per minute, armature on the shaft; 18x36-inch Brown engine, 12-foot flywheel; two Manning boilers 130 horsepower, 135 pounds pressure; 700-horsepower National feed water heater; 10½x11 Armington & Sims high-speed engine; 25 horsepower Fairbanks & Morse gas or gasolene engine; heavy duty type. J. F. Foster, 166 Devonshire St., Boston, Mass.

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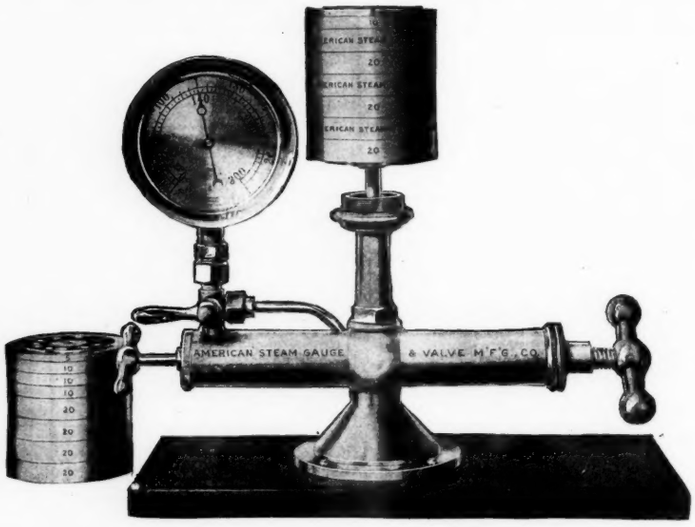

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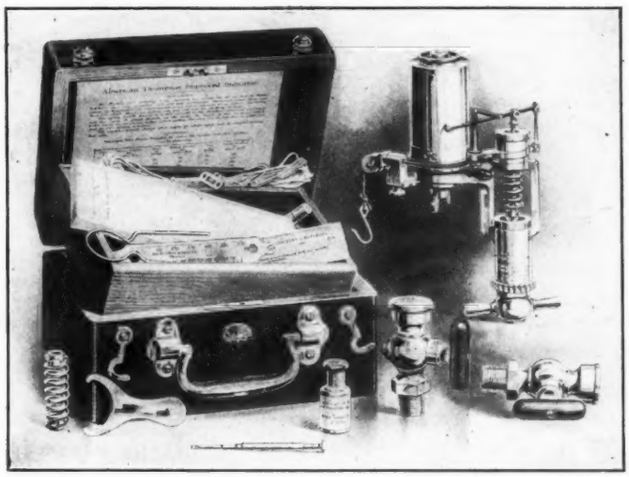

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Name of bearing where sample will be tested.....
Its width.....Combined horse power of engines.....
Tap size of cup.....
FIRM.....
Per .....
City .....State.....
Size cap required.....**CUT OUT THIS COUPON AND MAIL IT TO-DAY** Dept. B—10-17-11

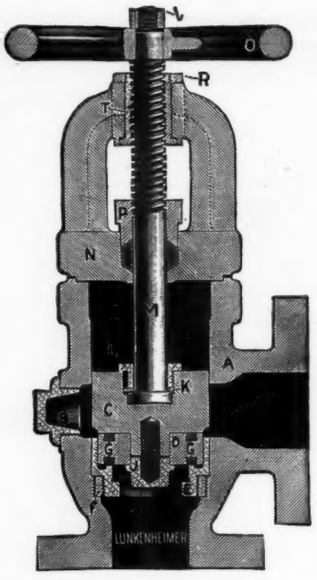
Lunkenheimer

is a name
well known in the engineering field.
It is synonymous with quality

"Duro"

is a name synonymous with durability,
and which when associated with
Lunkenheimer and

Blow-off Valves



is immediately recognized by engineers as the
trade name of a valve without an equal.

Lunkenheimer "Duro" Blow-off Valves

are guaranteed for 250 pounds working pressure. The body is made of cast iron having a tensile strength of 25000 pounds per square inch. And the bronze used contains a high percentage of copper and tin.

One of the principal advantages in the design of these valves lies in the construction of the seat and disc, which provide self-cleansing seating surfaces so that any scale or grit lodging on the face of the seat will positively be washed off before the disc is firmly seated, thereby insuring a perfectly tight valve.

The disc is double seated and can be reversed or renewed when worn. The seat is also renewable as are also all other parts of the valve subjected to wear.

Lunkenheimer "Duro" Blow-off Valves are made in sizes ranging from $1\frac{1}{4}$ inch to 3 inches inclusive.

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